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An Automated Tactical Operations Command, Control,
Communications, and Intelligence Planning Tool using
Hyper-NPSNET

by

Fikret SERBEST

March 1994

Thesis Advisor:	Dr. Michael J. Zyda
Co-Advisor :	LCDR John S. Falby

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13. ABSTRACT *(Maximum 200 words)*

The area of concern addressed by this research is the development of an Automated Tactical Operations Command, Control, Communications, and Intelligence Planning Tool (ATOC^{3}IPT) to aid commanders and their staffs in the decision-making process. The tool is based on Hyper-NPSNET, an application which integrates a single level hypermedia overlay into a 3D virtual world with at most a single instance of each type of multimedia information available at each 3D location. However, Tactical Operations Centers (TOCs) require multiple overlays, each with possibly multiple instances of each type of multimedia information available at each location. Also Hyper-NPSNET is a single user system whereas the TOCs require a multiple user system with restricted access.

Tactical information display and query retrieval requirements of the command and control organizations were studied. A database structure and control hierarchy were designed. An appropriate graphical user interface (GUI) was developed. The hypersystem used in Hyper-NPSNET was extended to include multiple, permission-protected overlays with multiple instances of each type of multimedia information available at each location.

The resulting ATOC^{3}IPT is a battlefield planning tool which incorporates today's technology. New hypermedia information display, editing, manipulating, and retrieval methodologies not available in Hyper-NPSNET are included. ATOC^{3}IPT is designed to be used by multiple users and with multiple overlays with multiple instances of multimedia information types, whereas in Hyper-NPSNET a single user can work with one single-level overlay. This tool assists the commander in the decision-making process, and provides an excellent training tool for staff officers.

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Fikret Serbest
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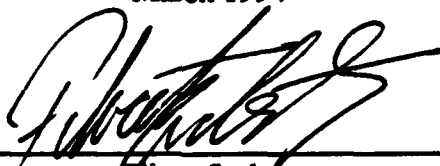requirements for the degree of

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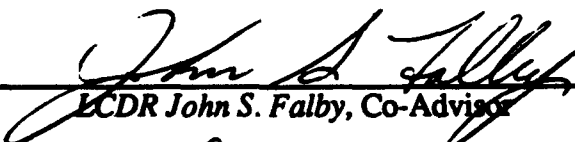
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Author: _____
Fikret Serbest

Approved By: _____
Dr. Michael J. Zyda, Thesis Advisor

_____
LCDR John S. Falby, Co-Advisor

_____
Ted Lewis, Chairman,
Department of Computer Science

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ABSTRACT

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ACKNOWLEDGEMENTS

DEDICATION

I would like to dedicate this thesis to my mother Zeburiye and father Huseyin who were my first teachers in life and who dedicated their lives for my well-being.

I. INTRODUCTION

A. BACKGROUND

Recent developments in high performance graphics workstations and digital terrain elevation databases have allowed researchers in the United States Naval Postgraduate School (NPS) Computer Science Department to produce some very good, low-cost, government owned simulators which run on commercially available graphics workstations. These include JANUS-3D and the NPSNET family, versions from one through four [Walter92] [Zyda93]. This research shows how the latest computer technology can be efficiently used to supplement the traditional processes used in the military. One of the most recent research developments underway is Hyper-NPSNET where multimedia is embedded into a real-time, interactive 3D virtual environment [Lombardo93].

B. MOTIVATION

Technological advances are not new to warfare. Throughout history, from the longbows of Agincourt to the tanks of Cambri, each advance has been met by a counter, either in technology or tactics [Wayne93]. The promise of technology as a force multiplier in the substitution of firepower mass for manpower mass has finally been realized. The success of the AirLand Battle doctrine in the Gulf War was due in large part to the integration of consumer electronics and software technology into military research and development. The equipment included portable computers that helped to manage everything from intelligence data to logistics information, the communications that tied together the C^2 network, locators (used in everything from Bradleys to B-52s) tied to GPS satellites, the laser guidance systems of Hellfire missiles on Apache helicopters and even the software that kept all the computers up and running.

Today commanders and their staffs rely on timely, accurate information to make key tactical decisions, and on reliable, secure systems to communicate those decisions and subsequently monitor performance against the plan. This need led to research effective

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ways to use today's state-of-the-art computer technology capabilities in the design of a decision support tool.

C. PURPOSE

The purpose of this thesis is to automate the tactical operations command and control planning process using the developing Hyper-NPSNET project. The proposed Automated Tactical Operations Command, Control, Communications and Intelligence Planning Tool (ATOC^{3}IPT) is a prototype decision support device for use in various tactical echelons of the Army (e.g.. Command Posts and Tactical Operations Centers).

D. METHODOLOGY

To accomplish the above mentioned purpose the methodology was:

1. Ascertain the tactical information, display, and query retrieval requirements of the command and control organizations.

2. Design the required database structure and hierarchy to support that tool.

3. Design an appropriate graphical user interface (GUI) for the proposed tool to incorporate the required tactical information, display, and query retrieval that the commander and his staff in the command and control organizations need.

4. Implementation of the Hyper-NPSNET system under the newly developed GUI for testing purposes.

5. Discuss the appropriate networking system between various echelons of the Army to support the proposed ATOC^{3}IPT.

6. Discuss both networking and database security requirements for the ATOC^{3}IPT.

7. Discuss the artificial intelligence and human factors to support the proposed system.

8. Discuss the advantages and disadvantages of such automation.

E. CHAPTER SUMMARY

In Chapter II, the technical and tactical terminology used throughout the thesis is introduced. Chapter III presents automation trends and provides information about the previous work done in the NPS Computer Science Department's Graphics and Video Laboratory which provided the basis for development of the $ATOC^3IPT$.

Chapter IV explains the development process of the command and control tool. In the first part of Chapter V, we discuss the design requirements of the communications network and its security. Database issues are discussed in the second section of this chapter. Then Artificial Intelligence support of the model and human factors are discussed in the third section. These are the support elements for the proposed tool. Advantages and disadvantages of command and control process automation are discussed in Chapter VI and recommendations for future work are explained. Chapter VII contains the $ATOC^3IPT$ user manual.

IL TECHNICAL AND TACTICAL TERMS EXPLANATIONS

A. TECHNICAL TERMS

Multimedia: A computer based method of presenting information by employing more than one medium of communication and emphasizing interactivity. The medium of communication may be data, text, image, animation, video and sound, or any combination thereof.

Hypertext: The nonsequential retrieval of a document's text. The reader is free to pursue associative trails through the document by means of predefined or user created links.

Hypermedia: A computer-assisted instructional application that adds Multimedia to the capabilities of a Hypertext system. In a Hypertext system, you select a word or phrase and give a command to see related text. In a Hypermedia system, such a command may also reveal related graphic images, sounds, and even snippets of animation or video [Bryan92].

Virtual World System: Any system that allows the user to interact with a three-dimensional computer-graphics generated environment [Zyda93].

Information Anchor: A 3D location in the virtual world that has an identity and the capability to attach audio, video, graphics or textual information. Synonym: Anchor.

Hyper Node: Simple object which contains one type of information (graphics, video, sound or text) and is attached to an Information Anchor. Synonym: Information Node or Node.

Hyper Link: A connection established between Information Anchors, and between an Anchor and its associated information nodes. Synonym: Link.

Hypersystem: A complete system of Anchors, Links and Nodes [Lombardo93].

SIMNET: A standard for distributed interactive simulations developed under DARPA auspices beginning 1985. The purpose of SIMNET is to facilitate early phases of training at a cost far below the expence of operating real vehicles or conducting real battlefield exercises.

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DIS (Distributed Interactive Simulation): Newer simulation standard than SIMNET. Many aspects of it are currently under development and refinement. DIS shares its goals and purposes with SIMNET, but is far more ambitious, allowing for greater complexity and realism. Examples: SIMNET uses flat terrain; DIS accounts for the curvature of the Earth. SIMNET is oriented towards terrain and the sky above it; the DIS world encompasses all areas of potential activity - earth, atmosphere, above and below the surface of the ocean, and space [Brackle93].

B. TACTICAL TERMS AND ABBREVIATIONS

Commander: Officer responsible for a unit's training and operations. The commander alone is responsible for all that his unit does or fails to do [Zurick92].

Staff: A commander's group of specialized advisors. The military staff is organized specifically to be a single, cohesive team which assists the commander in accomplishing the unit's mission [FM 101-5]. The organization and responsibility of the staff depends on the mission, regulations and laws. The staff organization of a Division is found in almost every echelon of the armed forces. Basically, a Division staff consists of Commander and five other officers, namely:

- Assistant Chief of Staff, G-1 (Personnel).
- Assistant Chief of Staff, G-2 (Intelligence).
- Assistant Chief of Staff, G-3 (Operations and Plans).
- Assistant Chief of Staff, G-4 (Logistics).
- Assistant Chief of Staff, G-5 (Civil-Military Operations).

The names of the staff officers vary depending on the command level and unit organization. In addition to these officers the staff may contain other specialized groups, such as ADA (Air Defence Artillery) officer, Liaison officers with various units related to the mission, FS (Fire Support) Coordinator, etc.

G-1: Personnel. Staff officer responsible for unit personnel issues, including:

- Unit strength maintenance.
- Personnel services support:
  -Replacement policies and requirements.
  -Unit strength and loss estimating.

-Morale support.
-Administration.
-Health services.
-Religious ministries.
-Legal services.
-Postal services.
-Finance services.
-Public affairs services, etc.
- Discipline, law and order.
- Civilian personnel.
- Administrative support of other personnel:
  -Enemy prisoners of war.
  -Augmentees.
  -Civilian internees.

G-2: Intelligence. Staff officer responsible for:

- Production of intelligence:
  -Preparation of intelligence estimate.
  -Intelligence Preparation of the Battlefield (IPB).
  -Development of essential elements of information (EEI)
  -Other intelligence requirements (OIR).
- Collection of information:
  -Ground reconnaissance.
  -Aerial reconnaissance (Army aviation and support services).
  -Surveillance.
  -Target acquisition.
  -Prediction of fallout for nuclear weapons employed by the enemy.
  -Technical intelligence.
  -Weapon information.
- Counterintelligence.
- Training.
- Security measures.

G-3: Operations and Plans. Staff officer responsible for:

- Operations:
  -Operation estimate.
- Tactical plan:
  -Fire support.
  -Electronic warfare (EW).
  -Psychological operations (PSYOP).
  -Deception.
  -Rear area protection.
  -Tactical troop movements.

- Miscellaneous activities:
  - Prediction of fallout for nuclear weapons employed by own forces.
  - Signal communications.
  - Location of command posts (CP).
- Organization.
- Training.

G-4: Logistics. Staff officer responsible for:

- Supply.
- Maintenance.
- Transportation.
- Control and administration of combat service support units.

G-5: Civil-Military Operations. The principal staff assistant to the commander in all matters pertaining to the civilian impact on military operations, and the political, economic, and social aspects of military operations on civilian personnel in the area of operations. G-5 is responsible for:

- Governmental activities:
  -Psychological operations.
  -Health and food services for the public.
- Economy:
  - Plan for restoring, maintaining, and improving the economy of the area.
- Public facilities:
  -Restoration and use of public services.
  -Plan for control of civilian traffic.
- Special: Protection of arts, monuments, and archives [FM 101-5].

Tactical Operations Center (TOC): The headquarters within which the general and special staff plan the conduct and support of current combat maneuvers.

Command Post (CP): The location of a unit's headquarters, commander, and his or her staff.

Intelligence Preparation of the Battlefield (IPB): This is the cornerstone to effective intelligence operations and the commander's scheme of fire and maneuver. IPB is the basis for situation and target development. IPB is a five-step process performed by G-2:

- Evaluation of the battlefield area.
- Terrain analysis.
- Weather analysis.
- Threat evaluation.

• Threat integration.

Figure 1 illustrates these steps. The first four steps of the process continuously revolve around the fifth step which serves as the nucleus of the IPB process: threat integration. In a low-, mid-, or high-intensity conflict, the process begins with an assigned area of operations [FM 34-1].

Command and Control: The exercise of authority and direction by a designated commander over assigned forces in the accomplishment of an assigned mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission [Coackley92].

Common Ground Station (CGS) : An automated system that gives the battlefield commanders near real-time information on the terrain, and enemy situation. The stand alone system is designed to take raw data from some intelligence collection platforms, and semi processed data from others. The overall objective of CGS is to speed up and enhance the intelligence collection and dissemination process. Figure 2 shows the conceptual drawing of CGS Collection Assets and Network [William92].

Scout: A human being equipped with binoculars, video cameras, and other vision assisting aids. The objective of a scout is information gathering.

GSR (Ground Surveilance Radar): Intelligence collection assets that can identify and locate moving target within their range.

RPV (Remotely Piloted Vehicle): Remotely operated vehicle equipped with video cameras. Capable of flying over enemy forces and confirming their composition and location.

JSTARS (Joint Surveilance and Attack Radar System): A US owned system that is similar to GSR in functionality. JSTARS is an airplane that identifies and locates moving targets over a large area.
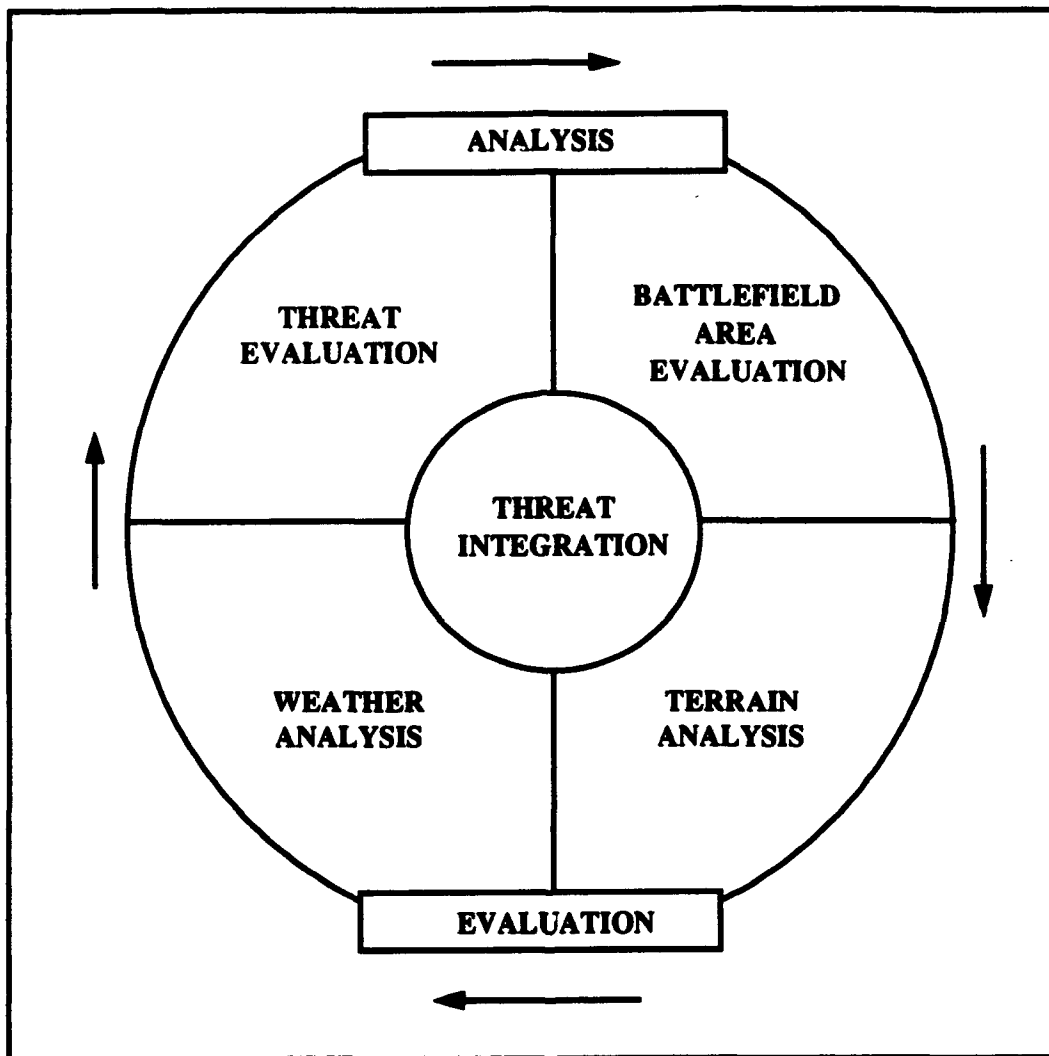
Figure 1 - IPB Process
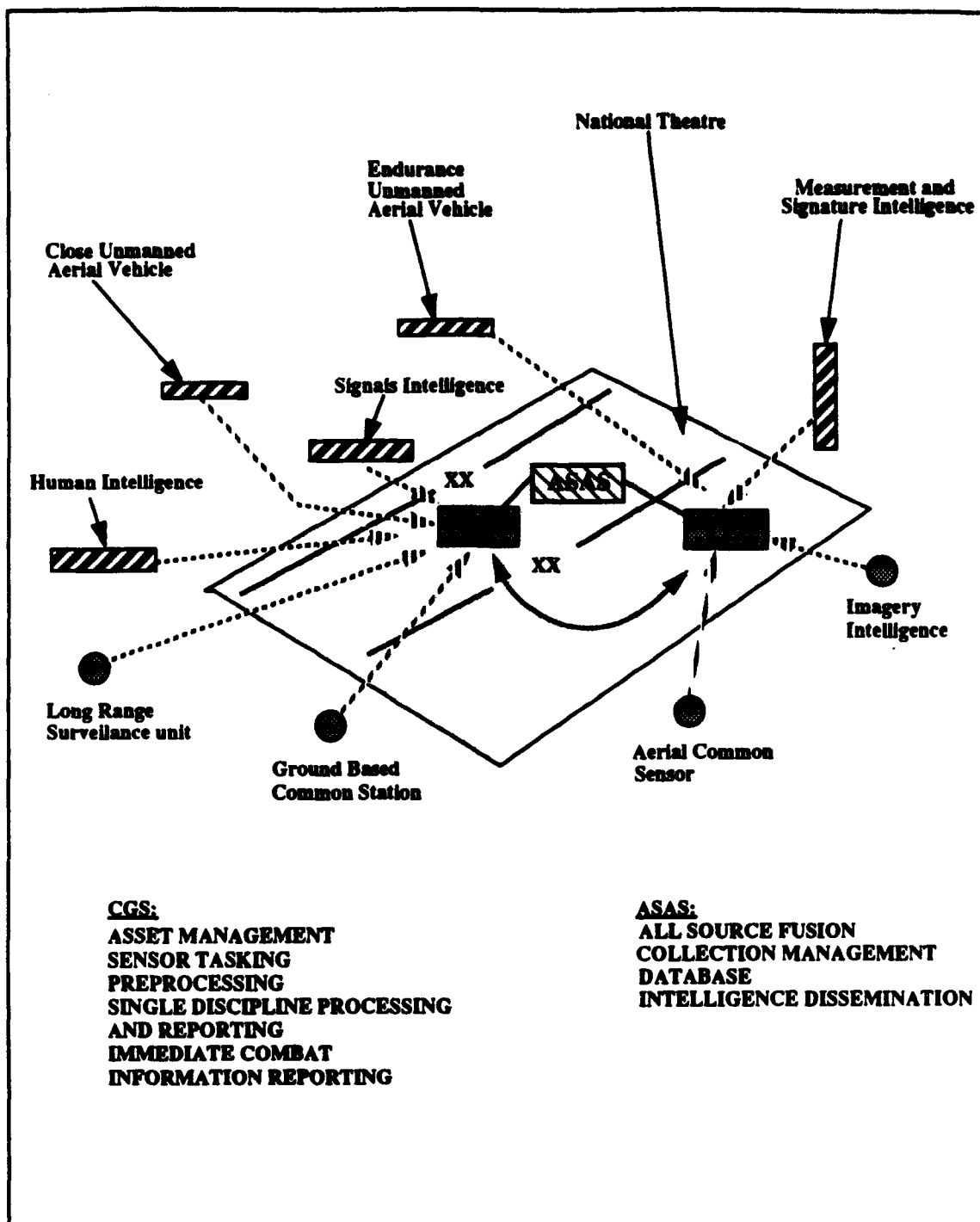
Figure 2 - CGS Collection Assets and Network

The figure contains the following labels:

- Close Unmanned Aerial Vehicle
- Endurance Unmanned Aerial Vehicle
- National Theatre
- Measurement and Signature Intelligence
- Signals Intelligence
- Human Intelligence
- XX
- ASAS
- XX
- Imagery Intelligence
- Long Range Surveilance unit
- Ground Based Common Station
- Aerial Common Sensor

CGS:
ASSET MANAGEMENT
SENSOR TASKING
PREPROCESSING
SINGLE DISCIPLINE PROCESSING
AND REPORTING
IMMEDIATE COMBAT
INFORMATION REPORTING

ASAS:
ALL SOURCE FUSION
COLLECTION MANAGEMENT
DATABASE
INTELLIGENCE DISSEMINATION

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III. PREVIOUS WORK

A. AUTOMATION TRENDS

During operations Desert Shield and Desert Storm computer technology was used extensively [Macedonia90]. The following models show the automation trends in military organizations:

1. **Engineering models for component design**

   (e.g., HYDRAULIC SYSTEM DESIGN)

2. **System engineering models**

   (e.g., MISSILE SYSTEMS DESIGN)

3. **Weapon system performance models**

   (e.g., VULNERABILITY ANALYSIS)

4. **Unit operations models**

   (e.g., ARTILLERY BATTERY OPERATIONS)

5. **Functional area models**

   (e.g., DESIGN OF AIR DEFENSE FORCES)

6. **Combined arms combat models**

   (e.g., EVALUATION OF ALTERNATIVE COMBAT FORCES)

7. **Command group training models**

   (e.g., BATTALION COMMAND GROUP TRAINING)

8. **Management models**

   (e.g., FORCE STRUCTURE ANALYSIS)

9. **Real-time planning models**

   (e.g., LINE-OF-SIGHT ANALYSIS) [Hughes89]

Such automation implementations and simulations showed how tasks that required days to accomplish could be reduced to hours. Simulations are also used to automate C^3I facilities. In essence, simulations resemble combat board games which use visual symbols to represent forces on maps that can be displayed on a computer screen, but most of the action goes on in the computer's memory banks.

Common Ground Station is a good example of an automated system that gives battlefield commanders near real time information on terrain and enemy situation [William92]. It is called a first generation reconnaissance and surveillance planning tool by the US Army.

Artificial intelligence, decision aids and intelligence fusion are also focused on meeting the information needs of the commander and staff in the decision-making process. As high-speed, real-time information exchanges were needed to guarantee that the commander has the right pieces of critical information in a timely manner to make necessary decisions, robust, continuous, secure communication networks were built.

Improvements in hardware also became necessary for the automation of units deployed far inside the front. High-speed, portable, rugged computers became necessary to support lighter, mobile, agile forces. Improvements in superconductors, array processors, modeling, graphics, robotics, video transmission, fiber optics, process control, and local area networks improved Army command and control support systems in the past and will continue to do so in the future.

B. JANUS

Janus is a "two-sided, interactive, closed, stochastic, ground simulation". It is "two-sided" because it allows the simulation of two opposing forces. It is "interactive" because each player monitors, directs, reacts to, and redirects all key actions of the simulated units under his control. The model is classified "closed" because the friendly force players do not know the complete disposition of the opposing forces. When a scenario is played on the model, certain events in the game, such as direct fires and artillery impacts, are

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"stochastically" modeled, which means that they act according to the laws of probability, and are thus different for every scenario run. The principal modeling focus in JANUS is on military systems that participate in maneuver and artillery operations on land, thus the term "ground combat simulation".

JANUS displays the terrain of operations in two dimensions. Researchers at the Naval Postgraduate School showed that a three-dimensional virtual world could be created from any existing JANUS terrain database. A scripting tool has been written which is capable of rendering JANUS scenarios on this three-dimensional terrain that were previously executed in the traditional two-dimensional model. A real-time, network link from the two-dimensional JANUS model to NPSNET has also been implemented [Walter92].

C. NPSNET

NPSNET is a low-cost, workstation based 3D visual simulator that utilizes SIMNET databases and SIMNET and DIS networking formats for virtual world exploration and experimentation [Zyda93] [Pratt93]. The project is being developed by researchers at the Graphics and Video Laboratory of the Department of Computer Science at the Naval Postgraduate School. NPSNET is a real-time, interactive, simulation system which is able to display real terrain, man-made and natural obstacles, as well as autonomous forces. As NPSNET is networked, players from various locations can interact with the same simulation. NPSNET became a family of virtual environment research systems as it evolved from versions one through four.

D. HYPER-NPSNET

1. Introduction to Hypertext System Architecture

Figure 3 shows a basic hypertext structure. The figure shows six nodes and nine links. Assume the user starts by reading the piece of text marked A. Instead of a single next place to go, this hypertext structure has three options for the reader: Go to B, D, or E. Assuming the user decides to go to B, he can then decide to go to C or to E, and from E he
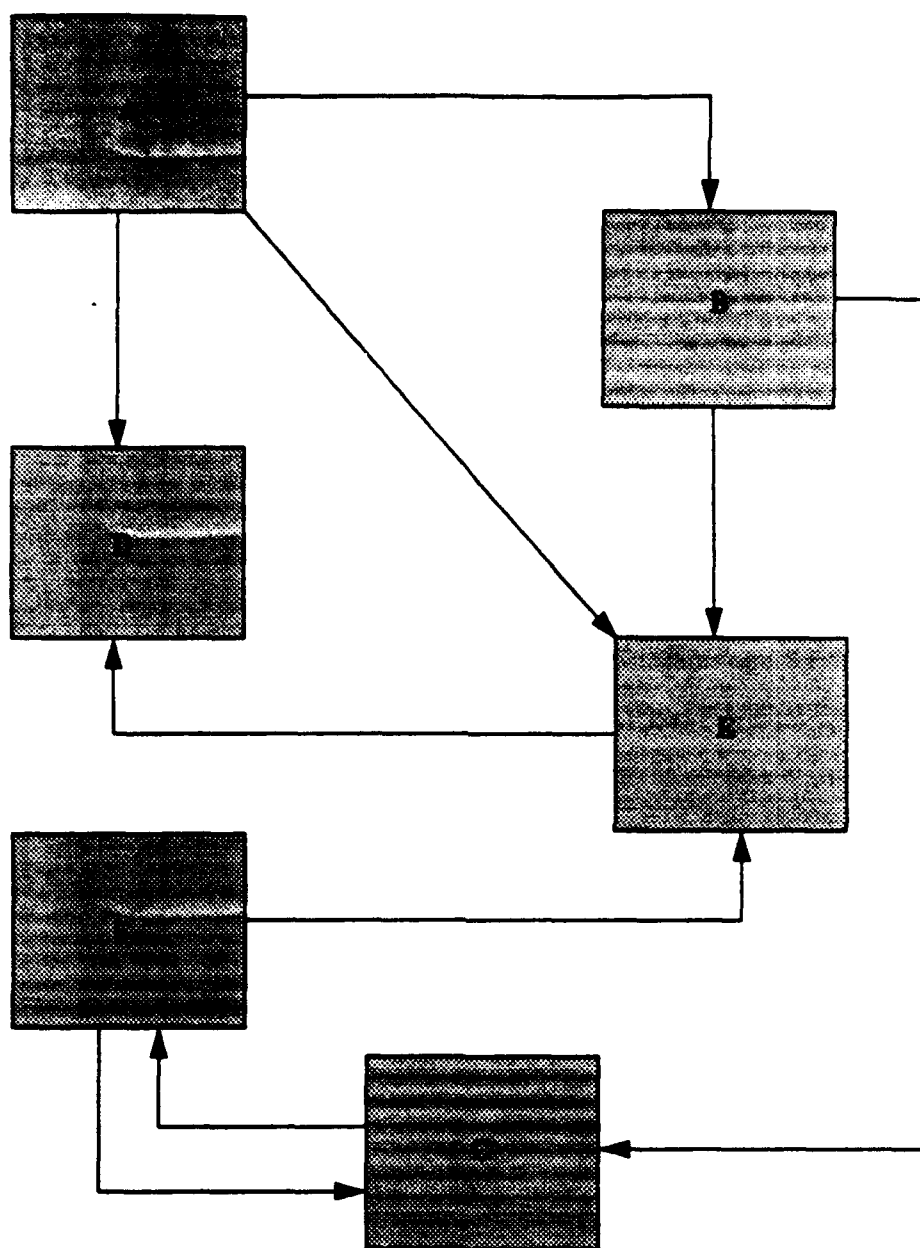
Figure 3 - Simplified View of a Small Hypertext Structure Having Six Nodes and Nine Links

can go to **D**. Since it was also possible for him to go directly from **A** to **D**, this example shows that there may be several different paths that connect two elements in a hypertext structure [Nielsen90]. This idea is the basis behind the design of Hyper-NPSNET [Lombardo93].

In theory, one can distinguish three levels of a hypertext system [Nielsen90]:

- Presentation level: user interface
- Hypertext Abstract Machine (HAM) level: nodes and links
- Database level: storage, shared data, and network access

The following sections describe each of the levels in further detail, starting at the bottom.

a. The Database level

The database level is at the bottom of the three-level model and deals with all the traditional issues of information storage that do not really have anything specifically to do with a hyper system. It is necessary to store large amounts of information on various computer storage devices like hard disks, optical disks, etc., and it may be necessary to keep some of the information stored on remote servers accessed through a network. No matter how the information is stored, it should be possible to retrieve a specified small chunk of it in a very short time.

Furthermore, the database level should handle other traditional database issues, like multi-user access to the information, and various security considerations, including backup. Ultimately it will be the database level's responsibility to enforce the access control which may be defined at the upper levels of the architecture.

As far as the database level is concerned, the hyper nodes and links are just data objects with no particular meaning. Each of them forms a unit that only one user can modify at one specific time and that takes up so many bits of storage space.

b. The Hypertext Abstract Machine (HAM) Level

The HAM sits in the middle between the database and user interface levels. This is where the hyper system determines the basic nature of its nodes and links and where

it maintains the relation among them. The HAM has the knowledge of the form of the nodes and links, and knows what attributes are related to each.

The HAM is the best candidate for standardization of import-export formats for hypertext, since the database level has to be heavily machine dependent in its storage format and the user interface level is highly different from one hyper system to the next. This leaves only the HAM, and since we do need the ability to transfer information from one hyper system to the other, we have to come up with an interchange format at this level.

c. *The User Interface Level*

The user interface deals with the presentation of the information in the HAM. Issues such as what commands should be made available to the user, how to show nodes and links, and whether to include overview diagrams or not are decided at this level.

2. Introduction to Hyper-NPSNET

Hyper-NPSNET is a real-time interactive virtual environment with embedded multimedia capabilities. Within the system, there is the notion of an information anchor. These anchors allow access to embedded multimedia information such as video, audio, textual and graphic media. In the current system, a user can navigate through these information anchors and manipulate them. The creation and modification of information anchors is made possible using the "Authoring" capabilities of the system.

Hyper-NPSNET is different from the other existing hypermedia applications where the user is constrained only to the hypermedia links and nodes. Within Hyper-NPSNET, the user can move throughout the virtual environment unconstrained. The user can navigate over 3D terrain even if there are no information nodes present.

Another unique feature of Hyper-NPSNET is the ability to attach up to four distinct types of media information to one physical location. Upon approaching an anchor, the user can query it for additional information. These queries can be for information about the current anchor's location and orientation in the world, or for playback/viewing of some audio or video track, text or image that has been attached to the anchor by the author of the

data set. The user can also select any anchor off a list of all nodes in the system. As these nodes are visited, links are established, allowing the user to "Back out" in the reverse order of the initial visits.

3. HYPERSYSTEM designed and used in Hyper-NPSNET

The hypersystem is defined as the fundamental data structures that hold individual node information and all underlying links that enforce the association between anchors and information nodes. Figure 4 shows the hypersystem architecture used in Hyper-NPSNET. At the lowest level resides the HyperNode. It is the basic information containing entity of the system. An example of a HyperNode is a reference to an audio file that contains an audio track. Above the HyperNode is the Anchor. The Anchor contains ("has a") up to four HyperNodes that can represent the audio, video, graphics, and text information associated with the anchor. A collection of anchors represents the HyperSystem. It is through the HyperSystem level that individual anchors are created, modified or destroyed.

a. HyperNode:

As mentioned above, the HyperNode is the fundamental information er ity of the system. The node is designed and implemented as a record which contains HyperNode's identification, node type, and a file name. Four node types: NODE_VIDEO, NODE_AUDIO, NODE_GRAPHIC and NODE_TEXT are recognizable and implemented. The file name contains the path to either audio, video, graphics or textual data related to the node type.

b. Anchor:

The Anchor corresponds to an abstract information container. It brings together the information within the HyperNodes that make up the Anchor. Associated with any Anchor, there can be audio, video, graphic or textual information attached. The user merely asks to see and/or hear the information and it is presented. The Anchor may contain

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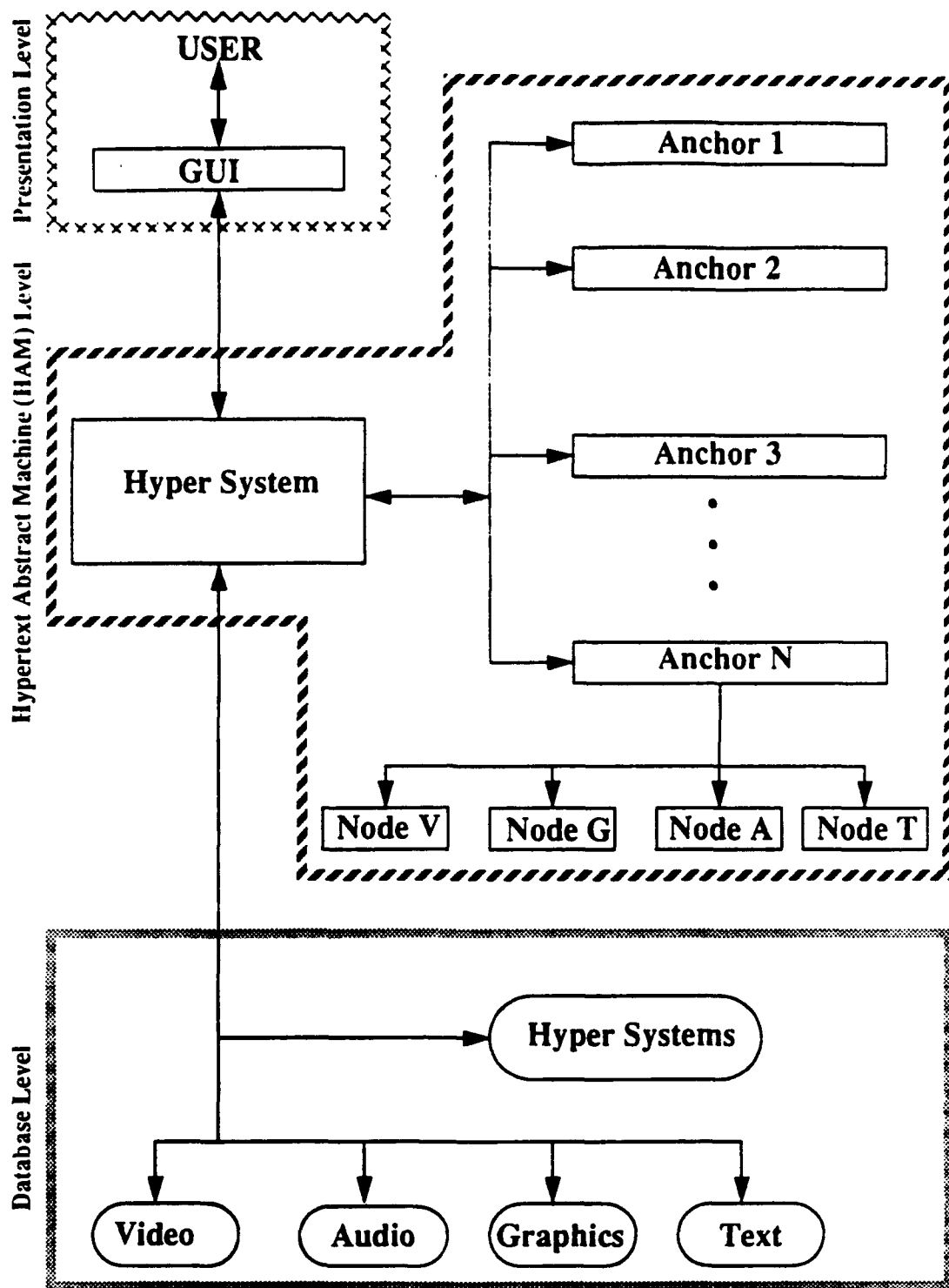
Figure 4 - HyperSystem Designed and Used in Hyper-NPSNET

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up to four HyperNodes. The Anchor stores the HyperNode identifications internally. This is done in the audio, video, graphic and text private variables which are unsigned integers and are unique for each Anchor thus guaranteeing no collision on the node level. In addition to node information the Anchor contains information related to itself. This includes it's own identification, which facilitates the Anchor search, querying and authoring, and it's type, which represents what kind of information object we are dealing with. Hyper-NPSNET recognizes only TERRAIN type. Also included is the Anchor name, which is displayed on the main control panel for Hyper-NPSNET (see Figure 5) and Anchor coordinates and orientation.

c. *HyperSystem:*

Once the anchors are designed, the information is assembled into a manageable object. This object is the HyperSystem. The HyperSystem object maintains information about the total number of anchors and total number of nodes in the system. In addition to this, a list of pointers to all anchors and a separate list of pointers to all nodes are maintained. HyperSystem locates both anchors and nodes using unique id. Anchor tables and node tables are kept for rapidly locating the address of an anchor or node given its id.

4. Graphical User Interface (GUI) designed and used in Hyper-NPSNET

OSF/Motif toolkit is used as a design tool for the graphical user interface of Hyper-NPSNET. The user interface consists of the main control panel that the user interacts with quite frequently and a collection of pop-up dialog boxes that present themselves when appropriate. All the panels and dialogs are responsible for updating themselves as the state of the simulation changes.

a. *Main Panel*

Figure 5 shows the main panel used in Hyper-NPSNET. This panel pops up when the application is started and stays open until the user exits the program. This is the

Figure 5 - Hyper-NPSNET Main Panel

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most frequently used window. It contains a menu bar from where the user can open other dialog boxes to manipulate the anchors or edit new ones, or to change the specifications of the simulation. Figures 6.1, 6.2 and 6.3 show the pulldown menus which can be initiated from the menu bar. By pressing the New option under the File pulldown menu, the user can create a new HyperSystem from scratch and give it a new name. The Open option pops up a dialog asking for a name of HyperSystem to be opened loads the system. There are Save and Save As buttons which are self-explanatory. There is also an Exit option which when pressed quits the application.

The Edit pulldown menu has two options: Anchor and Preferences. The Anchor option is used to popup the Anchor Editor of the system. The Preferences option is used to bring the Preferences popup dialog from where the user can change some simulation specifications.

The Display pulldown menu provides the user with the ability to turn Anchors on or off, to set the system to display only visible anchors, which are anchors inside a certain distance parameter to the user, or to set the texturing on or off. There is one rendering window displaying the 3D terrain and related objects.

The Hyper-NPSNET system allows the user to access all the information anchors in the virtual world by means of designated 3D interface devices. The user may fly around the world or drive on the terrain. When anchors are displayed, the user can simply select an anchor with the mouse and find himself at that specific point on the terrain.

Below the menubar there are text fields displaying the current anchor's identification, orientation and coordinates. There is a scrollable list from which the user may select the anchor of interest and from the buttons on the right side of this list can retrieve the information attached to that anchor. By pressing the Jump button beneath the list widget the user can jump to the location of the highlighted anchor. The view is displayed in the rendering window. The user may also back up from the present anchor through the anchors he visited before by pressing the Back button.

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```
┌─────────────────┐
│      File       │
├─────────────────┤
│ New             │
│ Open            │
│ Save            │
│ Save As         │
│ Exit       F3   │
└─────────────────┘
```

Figure 6.1 - Hyper-NPSNET Menubar: File Menu

```
┌─────────────────┐
│      Edit       │
├─────────────────┤
│ Anchor          │
│ Preferences     │
└─────────────────┘
```

Figure 6.2 - Hyper-NPSNET Menubar: Edit Menu

```
┌──────────────────────┐
│       Display        │
├──────────────────────┤
│ Anchors Off          │
│ Visible Anchors Only │
│ Turn Texturing On    │
└──────────────────────┘
```

Figure 6.3 - Hyper-NPSNET Menubar: Display Menu

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b. The Anchor Editor Panel

This is the popup dialog which is revealed when the user selects the Anchor option from the Edit pulldown menu. From this window the user may create a brand new anchor or may manipulate the data of an anchor already existing in the system. The user has to know the coordinates of the place where he wants to insert the information anchor. He also enters the path of the media file into the appropriate textfield provided in the dialog. Hyper-NPSNET can be used as an authoring tool for hypermedia. The user can build a new hypermedia database by using the Anchor Editor Tool. For existing anchors the user can modify the existing database of video, audio, text and graphic files (see Figure 7) [Daley92] [Lombardo93].

c. User Preferences Panel

The user preferences panel allows the user to specify the operating characteristics of certain features of the program (see Figure 8). From this dialog panel, the user can adjust the auto view distance, which means that when the user comes within the specified distance of any anchor the specified type of media will automatically be displayed. Also the user can modify the view distance parameter within which the anchors must be before they will be displayed. The user can also specify the movement type (fly or drive) and speed.

Figure 7 - Hyper-NPSNET Anchor Editor

Figure 8 - Hyper-NPSNET User Preferences

IV. DEVELOPMENT OF THE COMMAND AND CONTROL TOOL

There are several key issues affecting C^2 support system developments. The more prominent include:

- Affordability: Dominates system considerations as decreasing budgets force tough decisions on program developments.
- Interoperability: Essential at all levels. Within ATOC^{3}IPT compatibility is necessary to facilitate network management and eliminate the need for costly, system-unique interfaces.
- Integration: Integration of new systems means intensification of management efforts to ensure all the pieces, including supporting communications and additional equipment, are fielded and integrated in a synchronized manner to each operational force.
- Software: Software design, development and sustainment are the most expensive elements of automated C^2 systems and can easily escalate costs out of control if not carefully managed.
- Testing: Testing cannot be done in isolation, following traditional approaches. New systems must be designed and tested within Army Tactical Command and Control System (ATCCS) operating environment to ensure full integration and interoperability before full-scale development and production.
- Training: Must start early, be continuous and focus on commander and staff involvement [Wayne90].

A. DESIGN CONSIDERATIONS

As we consider that military forces throughout the world are downsizing, it is obvious that there will be fewer communications and automation officers to manage automation resources. Consequently, it is incumbent on all officers to have a working knowledge of automation, networks and the ability to transfer data. Given the rapidly multiplying sources of intelligence and inundation of raw data on enemy activities from sensors and other collectors, timely intelligence fusion is an immediate requirement. Decision aids are needed to assist the commander and staff officers in assimilating large amounts of information quickly; identifying the potentialities represented by the information, and making decisions/recommendations.

The Automated Tactical Operations Command, Control, Communications and Intelligence Planning Tool (ATOC^{3}IPT) is a model of a useful decision support element that can be used in various levels of the military. Due to the hardware specifications initially the ATOC^{3}IPT is designed to be used in brigade or division Command Posts or Tactical Operations Centers (see Figure 9).

The first design consideration was that this tool must accurately simulate, in some sense, the command and control process that is done in conventional Tactical Operations Centers. The second consideration was to determine the focus and the complexity level of the tool. Many discussions were conducted with people who actually served as staff officers in various branches and services.

During the design process many key questions arose which needed to be answered:

- Who are the users? What are their interests and concerns?
- What would a commander or a staff officer expect from such tool?
- How can the ATOC^{3}IPT best assure that the expectations of the users be fulfilled?
- In particular, what kind of information must the tool provide to the users, and what kind of information is going to be entered into the ATOC^{3}IPT database system?
- Finally, how can that tool be structured to make the necessary information exchange possible, likely and efficient?

While designing the ATOC^{3}IPT we followed these fundamental principles:

- Specified the objectives.
- Identified the users, their roles, and decisions they will be expected to make.
- Determined the information they will need to make those decisions, and identified the information feedback required to achieve the tool's objective.
- Designed the required interfaces for manipulating the data in the hyper-system.
- Designed the hyper-system and database to meet the requirements of information authoring and retrieval processes.
- Considered the possible networking environments.
- Kept the design simple but powerful.
- Tested and evaluated the design.
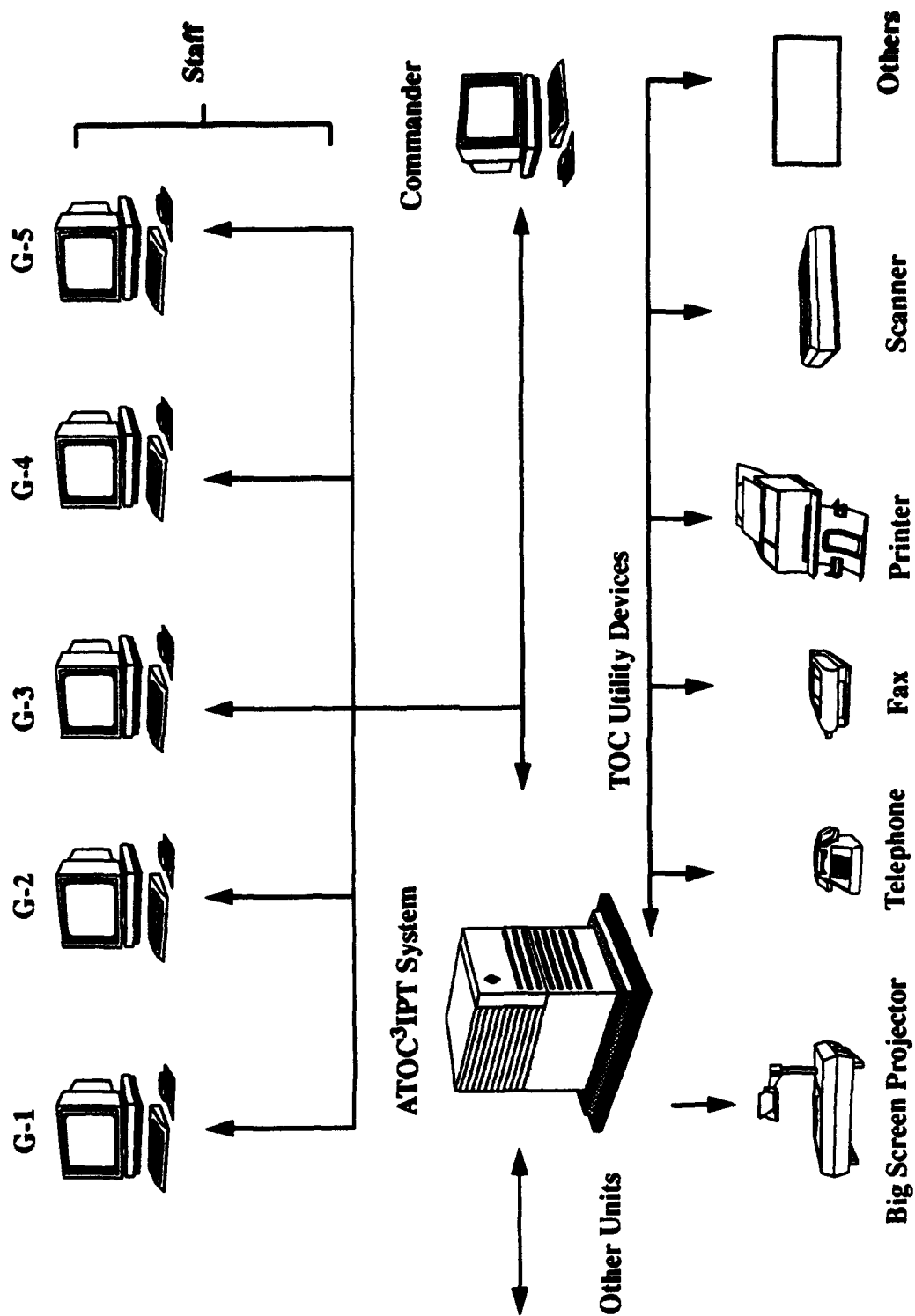
Figure 9 - Organization in the ATOC Using Hyper-NPSNET

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B. OBJECTIVES OF ATOC^{3}IPT

When we think of a TOC for a combat unit deployed in the field, the first things that catch our eyes are the various map boards which are used by the commanders and their staff, and which are essential to keep track of the enemy and friendly situation, and are the most important decision support tools. These map boards include some working map boards and situation boards. An effective arrangement of the maps and situation boards used in the TOC facilitates the combined efforts of operations and intelligence personnel to accomplish the best unit plans and orders while simultaneously allowing for independent operation by each of the sections [Johnston82]. These maps help the commander to grasp the situation at a glance. The staff officers work with water-based color pens, adhesive color dots, etc. to keep track of each unit and event, and continuously erase and redraw the related figures. Also sand tables are constructed to represent the three dimensional effect of the terrain. These manual applications are time consuming and unrealistic. They are time consuming because the staff officers spend a lot of time coloring maps instead of examining and solving the situation. They are unrealistic because even if an officer is excellent in map reading, it is not possible to create the exact three dimensional representation of the operational scene from sand and some other tools, especially if it is not seen. The commander or the staff may unexpectedly concentrate on some specific situation losing the overall view of the battlefield, which may lead to a catastrophic result. As a result the information process is becoming slow and sometimes far from being realistic.

To speed up the information process and accuracy, automation of these processes becomes inevitable. The ATOC^{3}IPT is one approach to automate these functions of the staff and provide the required decision support to the commander by combining today's state-of-the-art computer technology and hypermedia capabilities. Figure 10 shows the overall design of the ATOC^{3}IPT. The ATOC^{3}IPT is the nucleus from which the commander will be able to retrieve all the different types of information prepared by his
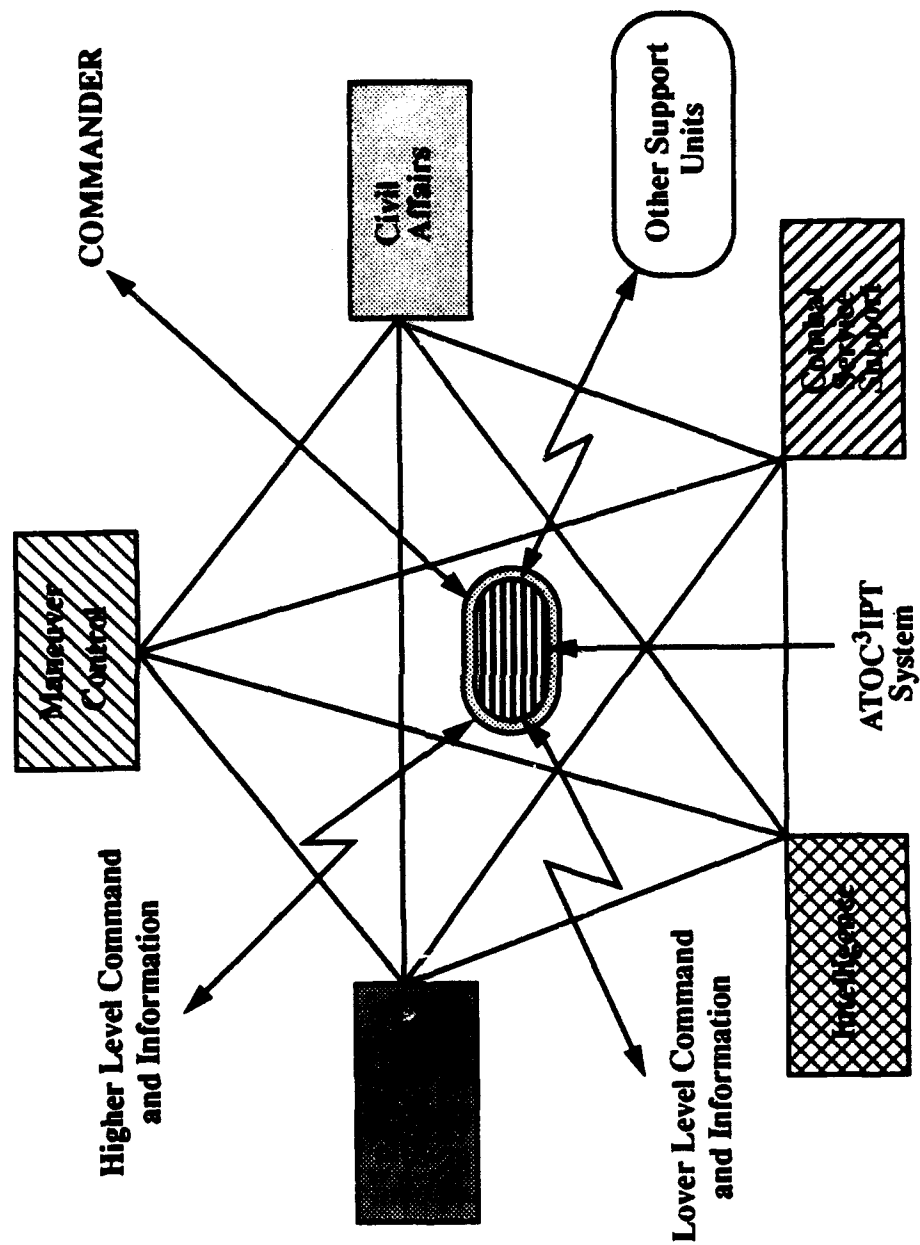
Figure 10 - ATOC^{3}IPT Using Hyper-NPSNET

staff. The proposed tool gives the required interface to the staff officers, namely Personnel (G-1), Intelligence (G-2), Operations (G-3), Logistic Support (G-4), and Civil Affairs (G-5), to be able to construct the scene of operations, create the necessary overlays in a matter of seconds, to embed information into the three dimensional information anchors which represents a unit, event, etc., and be able to communicate with related support elements, thus providing the commander with an excellent information presentation and decision support device. Figure 11 shows the data flow in the Automated Tactical Operations Center using ATOC^{3}IPT.

C. WHO ARE THE USERS

The users of the ATOC^{3}IPT are the staff officers and the commander. The commander is responsible for giving the order of operations as a result of examining the staff officers' recommendations and plans. He is responsible for the whole execution of the operational plan. He is given full authority to view all data in the hyper-system.The staff officers and their responsibilities considered during the design of the tool are defined in chapter one. They are only given authority to manipulate the data under their area of interest, but they also are able to access plans, overlays, orders, etc. prepared by other staff officers or commander with whom they must coordinate their work. Users are professionals with sufficient experience in the tactical operations planning process. They must have the basics of using the automation tools provided in the TOC. If they are not familiar with the equipment, it is vital to orient them via short introductory courses.

The tool may be used both by single and multiple users. By multiple users we mean the team of staff officers in TOC and, if the tool is networked, in use by other users who are manipulating the hypermedia database currently in use by ATOC^{3}IPT.

The main end user of the tool is the commander. All the staff works to support the commander in his decision making process by preparing operation plan related overlays, giving orders to support elements, obtaining and processing intelligence, keeping good record of the personnel, preparing logistic support plans, planning civil operations, etc.
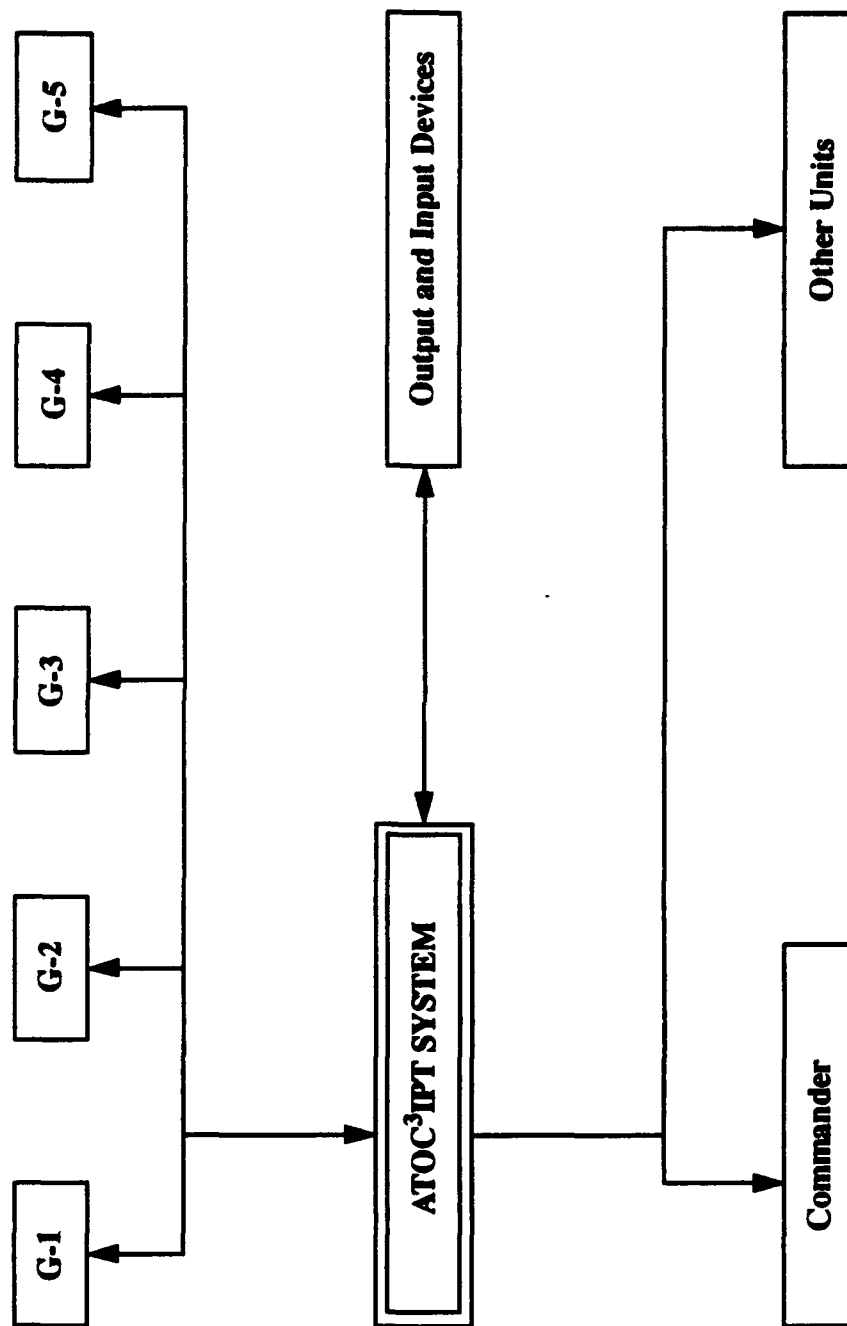
Figure 11 - Data flow in the Automated Tactical Operations Center

D. THE HARDWARE AND SOFTWARE REQUIREMENTS

1. Hardware requirements

a. System requirements

ATOC^{3}IPT is designed to run on commercially available Silicon Graphics, Inc. IRIS graphic workstations and all its embodiments. An additional hardware requirement is audio capability. Other hardware includes hard disk space, memory, input and output devices. As the audio and video files are very large, compression is advised. A video file is considered to fill at average about 10MB, and an audio file about 1MB of the disk. Also the terrain database, texturing, images, and text files may also consume a lot of disk space depending on the operation size and type. One other important hardware consideration is the amount of memory local to the workstation on which ATOC^{3}IPT is used.

b. Input devices

During the development of Hyper-NPSNET, a number of input devices were used to find the best navigation input tool. These devices include 6 degree-of-freedom Spaceball, the Ascension Bird, which is a 6 degree-of-freedom mouse, and standard 2D mouse. Considering the information process speed and need of simplicity in TOC's, we selected the standard three button 2D mouse to be used with ATOC^{3}IPT. The mouse is utilized in two states: move state and pick state.

When the mouse is in move state, the user can move forward by simply pressing the left button, backward by pressing the middle button, can stop and look around by pressing the third button. The turning is done by moving the mouse pointer right or left off the red rectangle which is shown when any mouse button is pressed. The user can look up or down by using the same technique but now moving the mouse up or down. When in pick mode, the left mouse is used to select the information anchors being displayed on the

terrain. The 2D mouse is a very practical solution for navigating in ATOC^{3}IPT virtual environment and is available on almost every workstation.

c. *Output devices*

Output devices include printers, video devices, fax-modems, big screen display devices, and additional speakers. In general, these are the tools that are found in TOC to help the staff in presenting their plans, preparing and sending the outgoing messages, etc.

2. Software requirements

For defining the 3D objects in the world, the locally developed NPS Graphics Description Language (NPSGDL) system is used [Wilson92]. For the display of image files, a package developed at NPS called NPSImage is used. All the code is AT&T C++3.0 compliant. The complete user interface is written in OSF/Motif version 1.1 on IRIX Version 4.0.5.

E. HYPERSYSTEM DESIGN OF THE ATOC^{3}IPT

Figure 12 shows the ATOC^{3}IPT HyperSystem architecture. The architecture is based on the Hypertext system design architecture defined previously while introducing Hyper-NPSNET. The ATOC^{3}IPT system consists of the user interface, the hyper-system and the hyper-system database.

1. Database design of the HyperSystem used in ATOC^{3}IPT

Figure 13 shows the ATOC^{3}IPT HyperSystem database design. ATOC^{3}IPT uses all precollected and stored data and the incoming data from various sources (scouts, unmanned aerial vehicles, satellites, units, etc.) deployed on the battlefield. There are various partitions of the main database. One part is designated to the previously created operational plans and exercises. These may be previously designed scenarios or executed plans. This partition allows the staff and the commander to reexamine and replay the old

exercise and comment on it. The creation of a scenario and editing and modifying of the database is described in the following sections. Another partition is designated for the precollected data used for designing a new plan and scenario. There is a partition for Weather where the environmental effects database is kept. Another partition is done for various Terrain databases. These databases include all the topological and physical information of the terrains. Blue forces and Red forces partitions exist in the database. These contain predefined information about various friendly and enemy units, and their personnel, organization, logistics, etc. The commander or the related staff officer may enter that database and link various information into the plan. In the HyperSystem database, there are also partitions for videos, graphics, audio, and text files. These files may be related to anything that may be used as information for the execution of the plan. For instance, photographs of unit personnel, video displaying the performance of a weapon, video obtained from scouts, etc. The database as a whole can be entered, modified, edited, and updated throughout the execution of the operational plan. How the user can reach that database is defined later in the next section.

2. ATOC^{3}IPT HyperSystem design

Figure 14 shows the design of the HyperSystem for ATOC^{3}IPT. The HyperSystem coordinates the data flow into and from the HyperSystem database in accordance with the expert system defined in the next chapter. The HyperSystem keeps track of all Information Anchors and Information Nodes. As is seen from the figure, there are five predefined types of operation. Each type of operation may contain multiple plans. Each plan contains five main information partitions, namely Personnel, Intelligence, Operations, Logistics and Civil Affairs. These information partitions contain the Information Anchors displayed by related overlays. Each Information Anchor contains video, audio, text, and graphics information files. There are also two general types of Information Anchor which are used independently of specific overlays, namely the Terrain Information Anchor and Unknown Information Anchor.
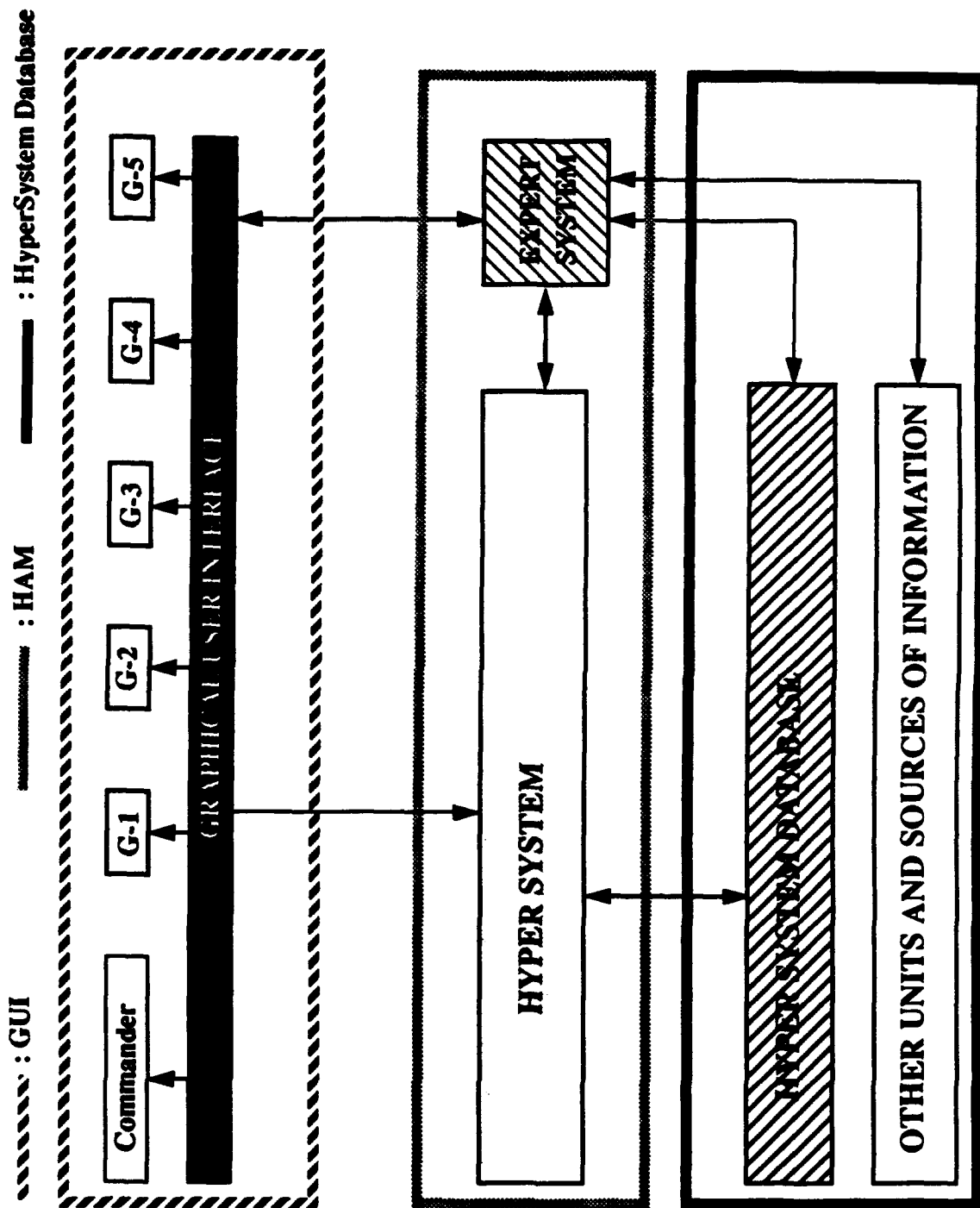
Figure 12 - ATOC³IPT System Architecture
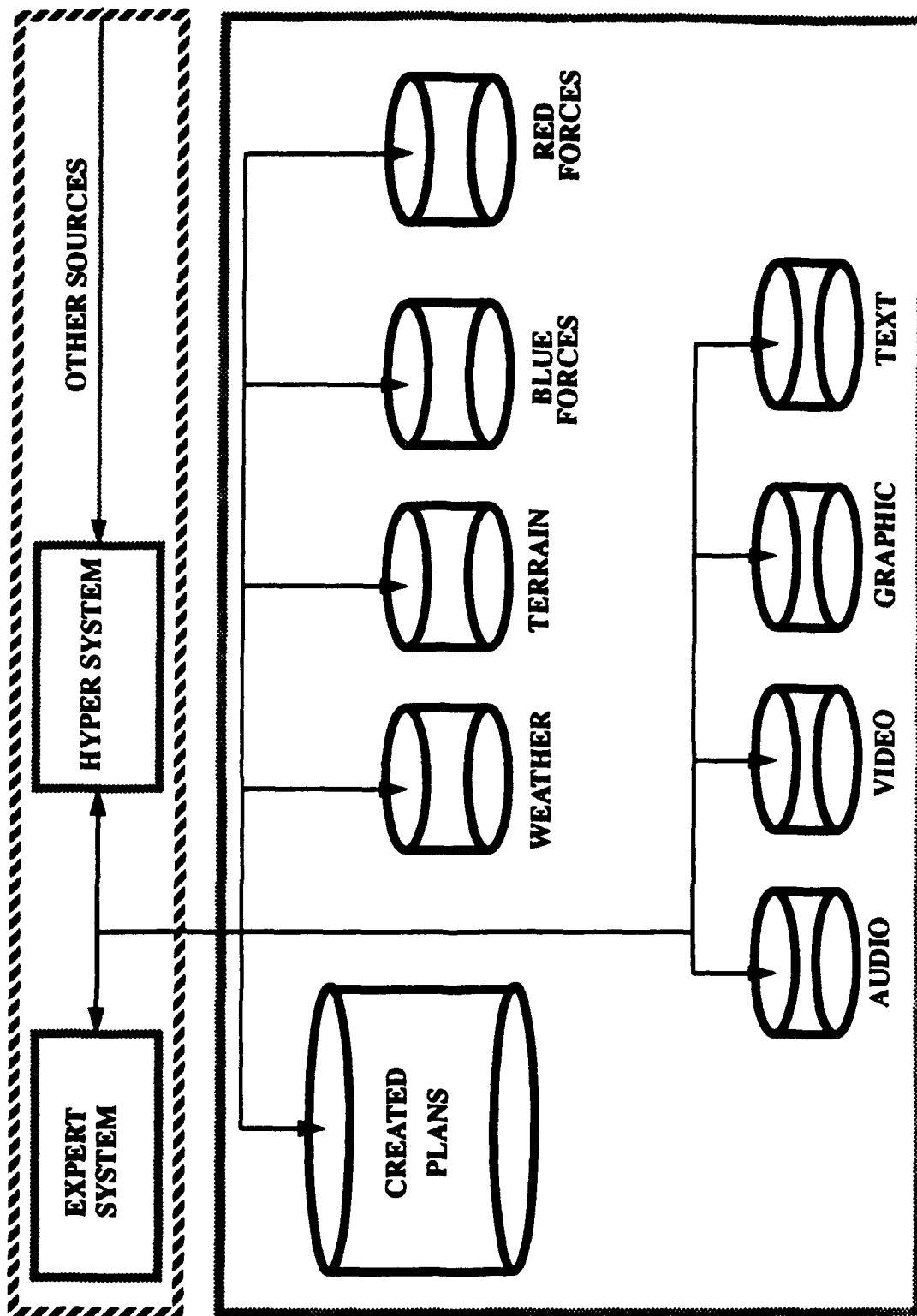
Figure 13 - ATOC^{3}IPT HyperSystem design
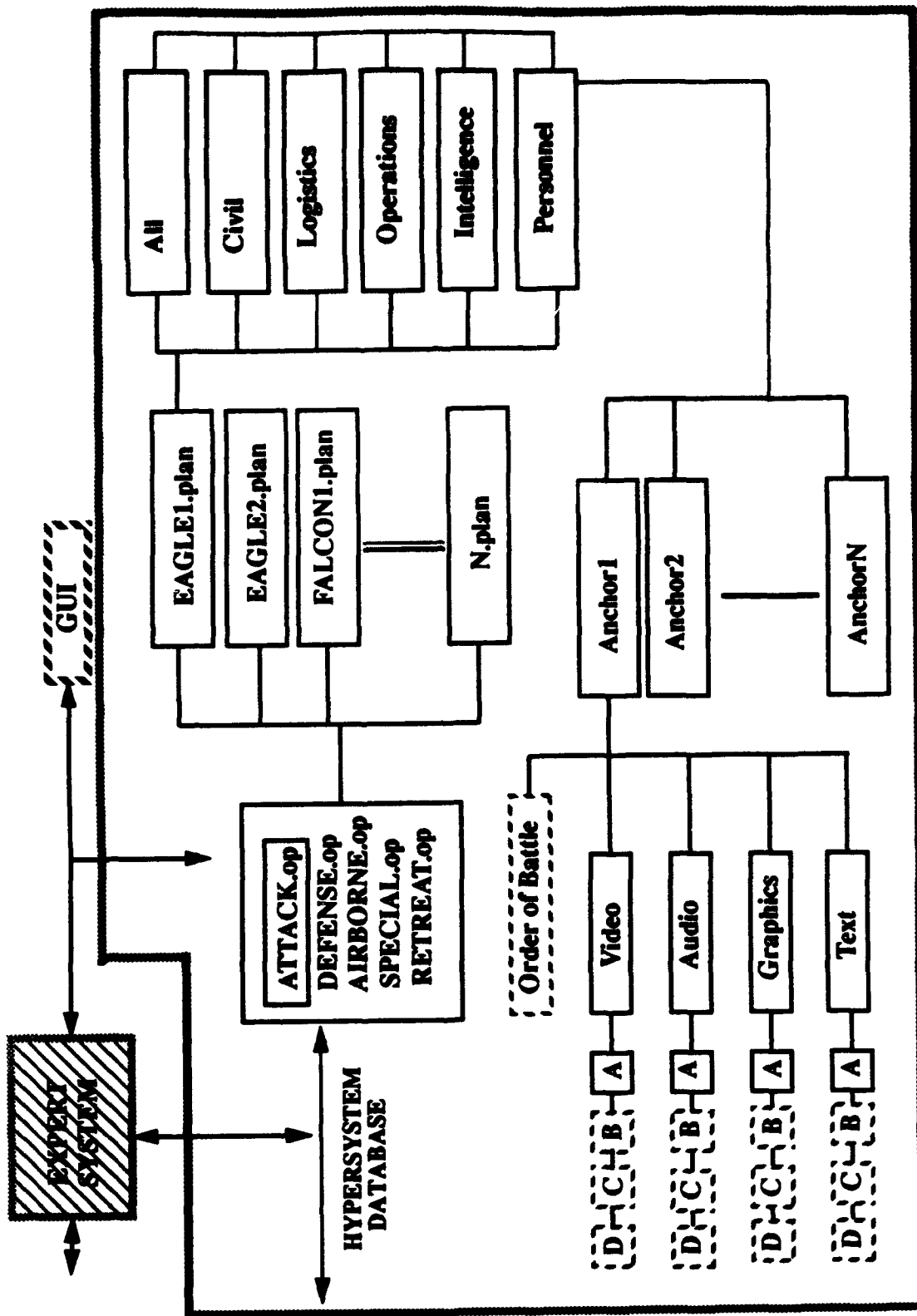
Figure 14 - ATOC^{3}IPT HyperSystem design

1. Introducing the Graphical User Interface (GUI) of ATOC³IPT

The figures defined in the next section describes the GUI of the ATOC³IPT. In general there are menus for editing and displaying operational plans and their related overlays. There are four main objectives of the GUI of ATOC³IPT:

- The user should be able to easily create a new plan scenario, or retrieve an existing one from the database.
- Editing and manipulating the HyperSystem database.
- Querying the HyperSystem database.
- Retrieval and display of the queried information.

A. DESIGN OF THE ATOC³IPT GUI

1. ATOC³IPT initializing window

How to work with the proposed tool is defined in Chapter VII, ATOC³IPT User Manual. When the user, let it be a commander of the staff in division TOC, starts the application, he receives the window showed in Figure 15. This is the application's initializing window and serves as the doorstep of the ATOC. This is designed as a dialog box where there are eight push buttons. Each button is self explanatory. For instance, the staff Personnel officer enters the system by pressing G-1 button. In Figure 16 the commander has pressed the "Commander" button and another popup dialog box is displayed. This dialog box is designed for security measures and asks for the security code of the person trying to enter the system. Each staff officer and the commander have their own security cod- ., thus they are entering the ATOC from different doors with their own keys. As the system is designed to have different features specific to the task of the operating personnel, this allows personnel to open only the application features related to him. When the commander enters the ATOC³IPT, the main application window pops up iconifying the previous window. The reason to iconify the previous window is that the commander can enter the system through any "door." If he wants to go back and enter the system as one of the staff officers he can do so by using the iconified dialog box.
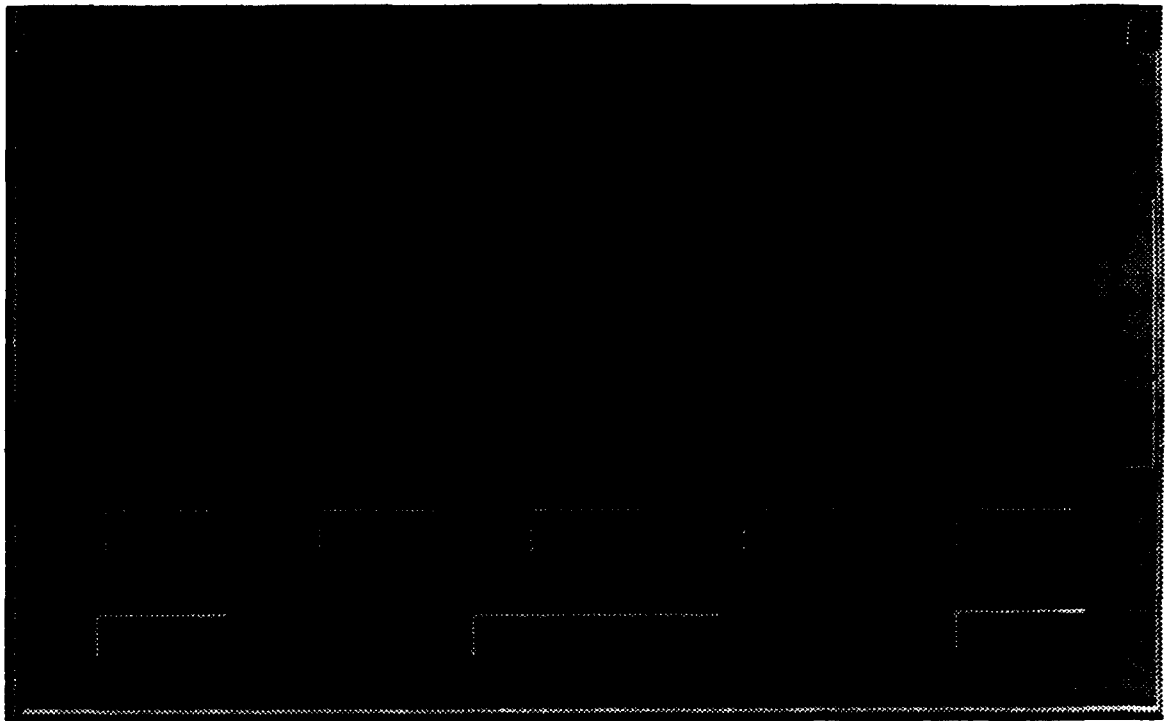
Figure 15 - ATOC^{3}IPT Initializing Window
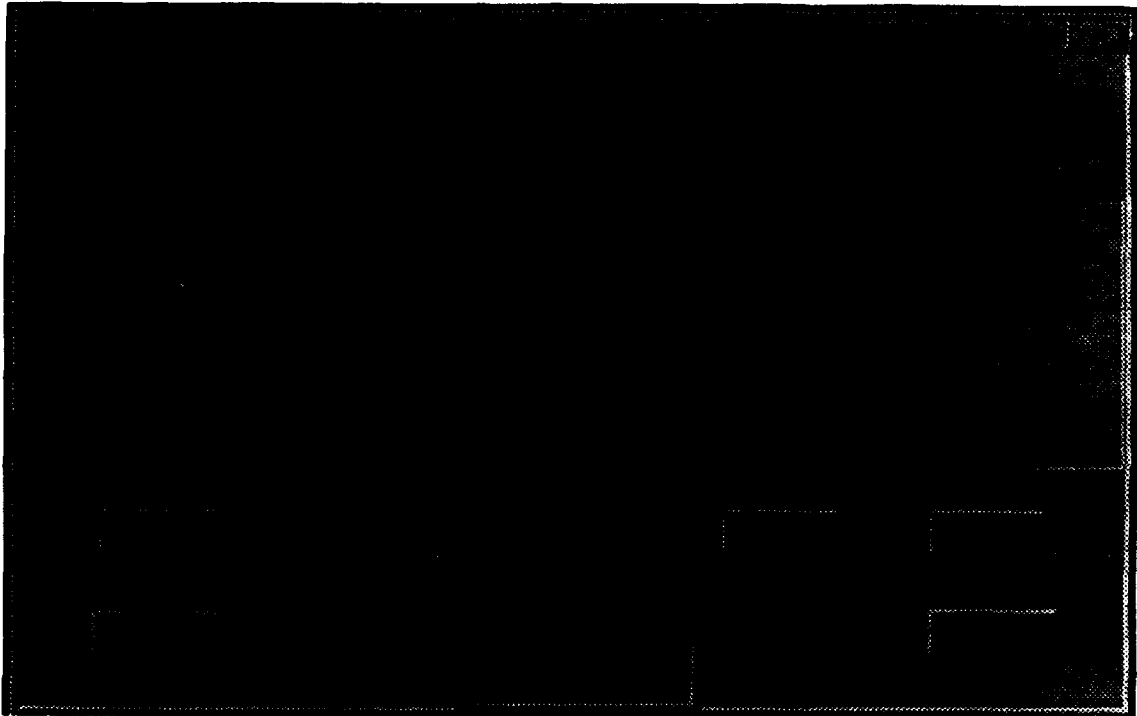
Figure 16 - ATOC^{3}IPT security check

In the main application window, there is a menu bar containing pulldown menus shown in Figures 17.1 through 17.5. There is a window displaying 3D terrain, which is a kind of virtual sand table. It opens with a default terrain of 2km x 2km. This default may be changed to any desired terrain. Below the terrain display, there are two radio buttons showing the state of the mouse. The user can set the mouse to move mode or query mode.

When the move mode is selected, pressing the left button moves the user viewpoint forward, pressing the right button moves his viewpoint backward. The user can choose the movement type to be "fly" or "drive" and can adjust the speed of the movement from View dialog box. B‍ ‍essing the right button the user can stop his movement and look around to a desired ‍ ‍tion, by simply adjusting the mouse cursor out of the red square toward that direct:

When the query mode is selected, the user can pick any of the displayed Information Anchors by pointing it with the mouse cursor and pressing the left button. Then the Anchor Information Display dialog box pops up with the name of the selected Information Anchor highlighted.

Figure 17.1 shows the Plan pulldown menu. This menu is used when a new plan is to be created (New) or an existing plan is to be opened (Open), saved (Save) or renamed (Save As). The Exit option is used to quit the application.

Figure 17.2 shows the Edit pulldown menu, which is used to edit various overlays, order of battle, Information Anchors independent of overlays, etc. The Edit menu contains the following options:

- Overlay: Provides the user with auto editing tools to create the following
  overlay types:
  -Personnel
  -Intelligence
  -Operations
  -Logistics
  -Civil Affairs
- Order of Battle: Provides the user with the Order of Battle editor.
- Anchor...: Provides the user with the manual Information Anchor editor. Here
  the user enters the type, orientation and coordinates of the created anchor

Figure 17.1 - ATOC³IPT Main Application Window Menubar: Plan Menu
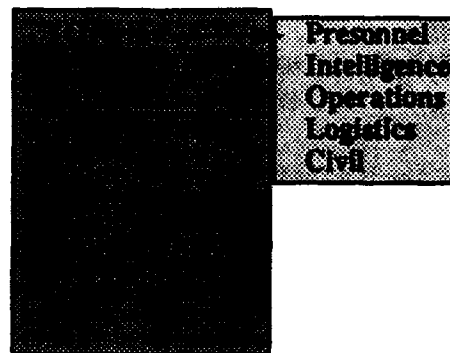
Figure 17.2 - ATOC³IPT Main Application Window Menubar: Edit Menu

himself.
- Text...: Provides the user with a text editor.
- Video...: Provides the user with a video desktop utility to edit various types of videos, and even tools for video conferencing.
- Audio...: Provides the user with audio editing desktop.
- Audio-Video...: Provides audio-video blending and editing tools.
- Graphics...: Provides image processing desktop.

The Text, Video, Audio, Audio-Video, and Graphics may be defined to bring up user defined programs to perform the respective function. When appropriate hardware and software are implemented into the system, the user will be able to edit hypermedia databases; videos, audio-videos, graphics, etc.

Figure 17.3 shows the display options of the tool. The user can set the texturing on or off, observe the weather conditions, reset the view point to initial state if disoriented in the terrain, select which type of overlay is to be displayed on the 3D terrain, query Information Anchors depending on their types, or break the units into their subunits using this menu:

- Overlay: Presents selections for controlling the display of the various overlays related to the plan opened. If an overlay is already On, the menu display will allow the user to turn it Off, and vice versa.
  -Personnel Overlay On
  -Intelligence Overlay On
  -Operations Overlay On
  -Logistics Overlay On
  -Civil Affairs Overlay On
  -All Overlays On
- Anchor: Presents selections for the display of information concerning anchors and associated nodes. When one is selected the Anchor Information Display dialog box (Please see Figure 33) pops up. Selections:
  -Personnel
  -Intelligence
  -Operations
  -Logistics
  -Civil
  -All: Includes Terrain and Unknown Information Anchors.
- Echelon: This option provide the user the ability to travel between the echelons. For example, by selecting the Battalion option when the current setting is Brigade, the Brigade decomposes into its battalions and now display shows information anchors related to displayed battalions. This allows the

user to travel from upper level echelons to platoon level and reverse. Thus a brigade commander can retrieve any available hypermedia information related to a platoon, or even personnel of that platoon.
   -Brigade
   -Battalion
   -Company
   -Platoon
   • Texturing On: Sets the terrain with appropriate physical conditions.
   • Weather: Displays a dialog box of the environmental settings by accessible only by S-2 or the commander.
   • View: Displays a window from where the user can select his motion type, speed, can view his coordinates, and can retrieve and view any hypermedia information located in the hyper-system database.

Figure 17.4 displays the Desktop menu options. Using this menu, the user can operate the devices which are in the ATOC and are connected to the workstations. He can print or fax a situation map, which may be a snapshot of the operations and intelligence overlays displayed on the selected 3D terrain. He can send email to various units, etc., or he can use a hypermedia-type library of the field manuals related to the unit type. When he presses the All option, another icon container window pops up containing icons of the above mentioned operations.

Figure 17.5 shows the Help menu options. Here the user can obtain information related to operating the ATOC^{3}IPT. There is an index option, listing sections about which there is help. There is a User's guide, and About Version option giving information about the designed model.

3.   New dialog box

As mentioned earlier, under the Plan pulldown menu there is a New option. The commander uses this option to create a new operation scenario. Figure 18 shows this popup dialog box. There is a text field where the commander enters the new plan name. Then he selects the terrain type from the option menu in the dialog box provided by the system depending on the terrain database. He selects the operation type. For the moment there are: Attack, Defense, Airborne, Retreat, and Special options to select from. Under these two
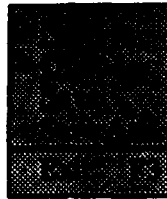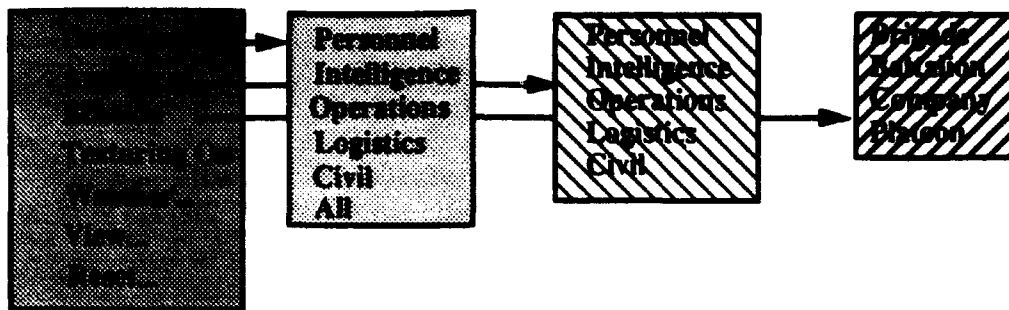
Figure 17.3 - ATOC³IPT Main Appliication Window Menubar: Display Menu
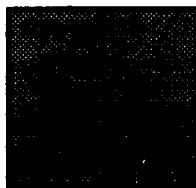
Figure 17.4 - ATOC³IPT Main Application Window Menubar: Desktop Menu

Figure 17.5 - ATOC³IPT Main Application Window Menubar: Help Menu

option menus there are four drawn buttons, which are self explanatory. Blue unit button, Red unit button, Weather button, and Time button. From these buttons, as explained later, the commander designs the four essential factors for the operation to be planned. When he presses enter then the hyper-system and the expert system get the database sections which are going to be used throughout the execution of the operation.

4. Blue forces and Red forces popup dialog boxes

This selection dialog box gives the commander the ability to select his own task force (Blue forces) which will be used to execute the operation (see Figure 19). By selecting the units given by the system, he selects the databases about them.; their personnel files, capabilities, organization, structure, etc. After choosing the desired units the commander gives that task force a name, and when he selects Apply button the hyper-system knows which part of the Blue forces database it is going to use. The same method is used to select the opponent forces (Red forces), if known (see Figure20).

5. Weather popup dialog box

Figure 21 shows the Weather dialog box, which is activated from New dialog box. This dialog box may be filled both by the commander or the intelligence officer. There are text fields for illumination conditions, humidity and temperature. There are eight option menus which give the user the ability to adjust the environmental effects for the operation:

- Cloud cover (Code and Explanation)
  - -0 clear
  - -1 None
  - -2 Scattered
  - -3 Scattered (hills in clouds)
  - -4 None
  - -5 Broken
  - -6 Broken (hills in clouds)
  - -7 Overcast
  - -8 Overcast (hills in clouds)
  - -9 None
- Direction of surface winds (Code digit, Explanation, Degrees)
  - -0 Calm None
  - -1 Northeast (NE) 023 to 067

47
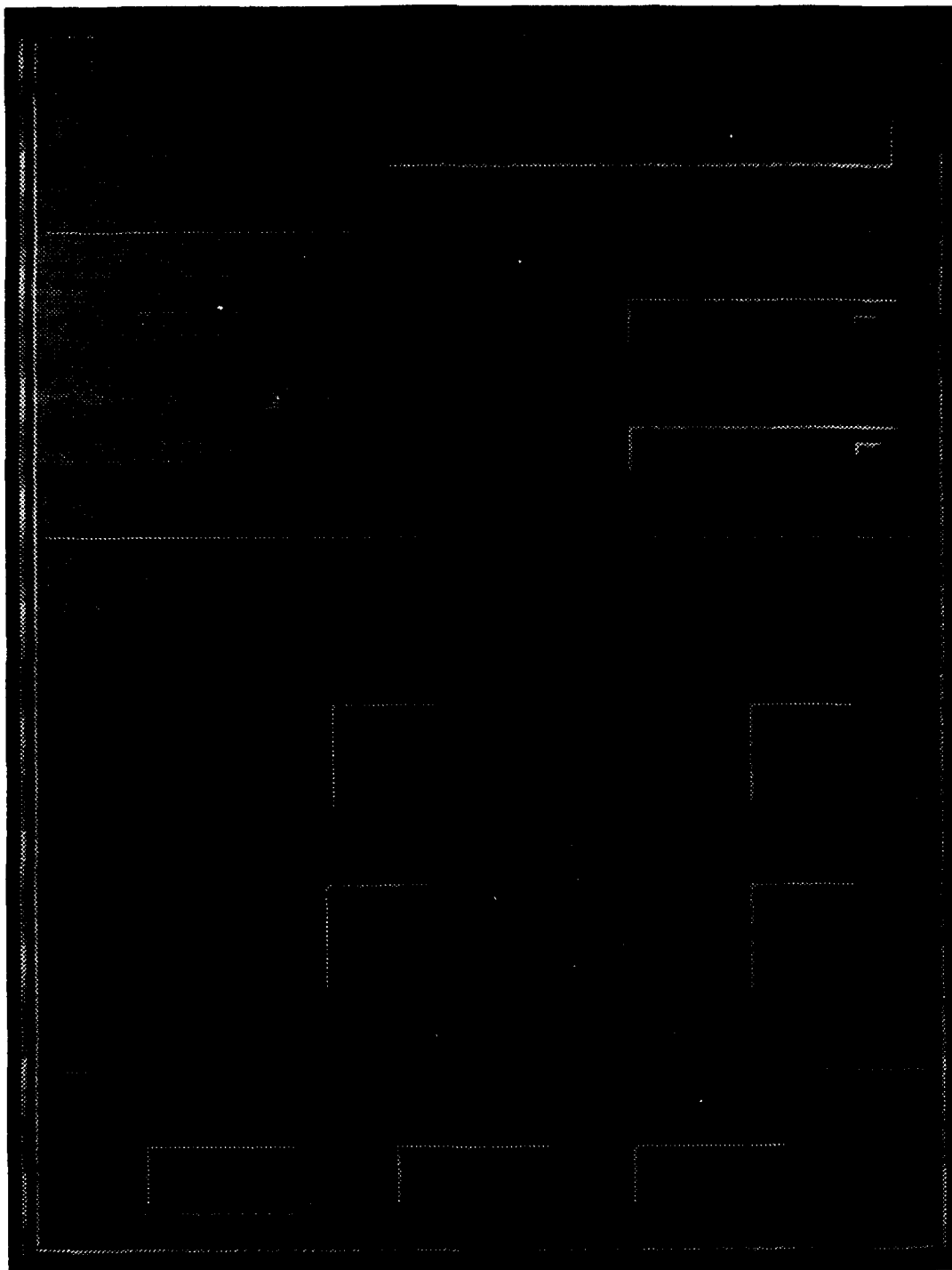
Figure 18 - Plan Pulldown Menu Option New Popup Dialog Box
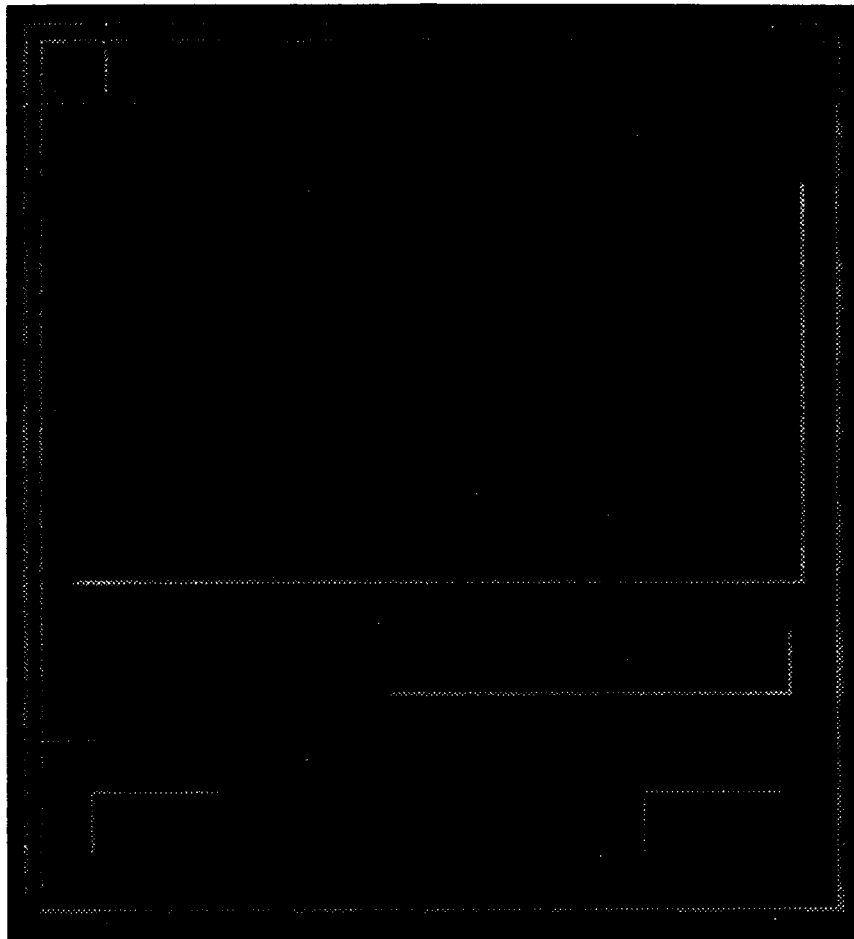
Figure 19 - Blue Forces Popup Dialog Box
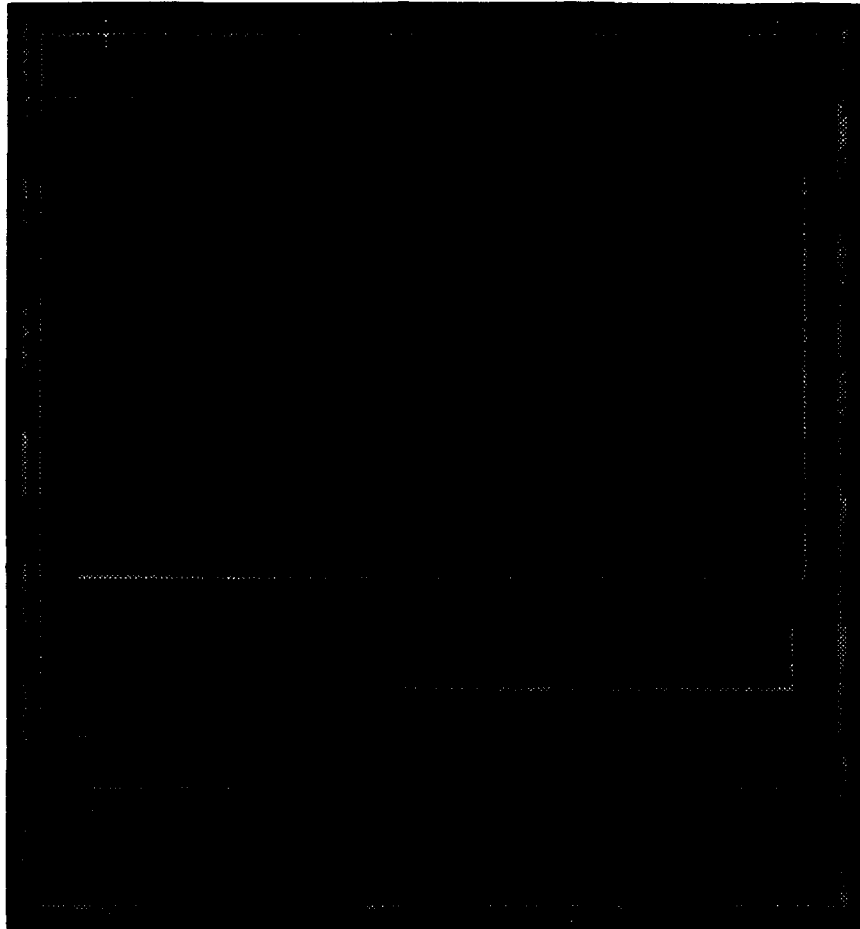
Figure 20 - Red Forces Popup Dialog Box

Figure 21 - Weather Popup Dialog Box

-2 East (E) 068 to 112
-3 Southeast (SE) 113 to 157
-4 South (S) 158 to 202
-5 Southwest (SW) 203 to 247
-6 West (W) 248 to 292
-7 Northwest (NW) 293 to 337
-8 North (N) 338 to 022
-9 Variable None
- Force of surface winds (Code, Explanation, Miles per hour)
  -0 Calm Less than 3
  -1 - -
  -2 Light breeze 4 to 9
  -3 - -
  -4 Moderate breeze 10 to 19
  -5 - -
  -6 Strong breeze 20 to 29
  -7 - -
  -8 Gale 30
- Visibility of the surface (Code, Explanation)
  -0 <164 ft. (<50m)
  -1 164 to <656 ft. (50 to <200 m)
  -2 656 to <1,640 ft. (200 to <500 m)
  -3 1,640 to <3,280 ft. (500 to <1,000 m)
  -4 3,280 ft. to <1.2 miles (1 to <2 km)
  -5 1.2 to <2.48 miles (2 to <4 km)
  -6 2.48 to <6.21 miles (4 to <10 km)
  -7 6. 21 to <12.42 miles (10 to <20 km)
  -8 12.42 to <31.06 miles (20 to <50 km)
  -9 >31.06 miles (>50 km or more)
- Present weather and obstruction of vision (Code, Explanation)
  -0 No significant weather
  -1 Smoke or haze
  -2 Fog in valley
  -3 Sandstorm, duststorm, or blowing snow
  -4 Fog
  -5 Drizzle
  -6 Rain
  -7 Snow or rain and snow mixed
  -8 Showers
  -9 Thunderstorms with or without precipitation
- State of roads (Code, Explanation)
  -0 Dry
  -1 Wet

-2 Flooded
-3 Slush
-4 Ice patches
-5 Glazed ice
-6 Snow depth 0 to 7.48 inches (0 to 19 cm)
-7 Snow depth 7.87 inches or more (20 cm or more)
-8 Snow drift
-9 -
* State of terrain (Code, Explanation)
-0 Dry
-1 Wet
-2 Pools of water on surface
-3 Flooded
-4 Ground frozen 0 to 1.5 inches (0 to 4 cm)
-5 Ground frozen 1.97 to 9.45 inches (5 cm or more)
-6 Snow depth 0 to 1.5 inches (0 to 4 cm)
-7 Snow depth 1.97 to 9.45 inches (5 to 24 cm)
-8 Snow depth 9.45 to 17.32 inches (25 to 44 cm)
-9 Snow depth >17.32 inches (45 or more)
* State of water surface (Code, Explanation)
-0 Water level normal
-1 Water level much below normal
-2 Water level high, but not overflowing
-3 Banks overflowing
-4 Floating ice (more than half)
-5 Thin ice 0 to 1.5 inches (0 to 4 cm) thick, complete cover
-6 Ice depth unknown, complete cover, passable for persons
-7 Ice depth 1.97 to 3.54 inches (5 to 9 cm)
-8 ice depth 3.93 to 9.44 inches (10 to 24 cm)
-9 Ice depth >9.48 inches (25 cm or more) [FM 34-81]

6. Time popup dialog box

Figure 22 shows a dialog box which is opened by pressing the time drawn button in the New plan dialog box. It allows the user to adjust the current time and the time of operations. By doing this the user sets the internal clocks of the hyper-system and the expert system, so that they can follow the time-specific issues given in Orders of Battle and display Information Anchors at specific times for the commander or the related staff officers. The time information is entered into the designated text fields and the user sets the

time by pressing the Done button, or closes the dialog with the Cancel button. It also has a Help button.

7. Open popup dialog box

In Figure 23 the Open dialog box is shown. It is initiated when the user selects the Open option from the Plan pulldown menu. Here the database about plans is displayed and existing plans under the preferred type of operation are listed on the left side of the selection list. The user can select one of the existing plans and when he selects apply, all links to related databases are established. The hyper-system loads the selected plan and its related information and sets them ready to be displayed in the order the user specifies them. There is an option menu containing predefined operation types. The user may select different operation types and, as each operation type may contain more than one related plan the system sets the plan search mask to the selected operation type and displays the existing plans in the Plans selection list. The default operation type is Attack. The name and the path of the selected plan is displayed in the text field located below the Type of Operations option menu. There are also Cancel and Help buttons, which are self explanatory.

8. Save As popup dialog box

Figure 24 displays the Save As dialog box which is used to rename the existing plan or the newly created one. It is initiated by selecting the Save As option from the Plan pulldown menu. The user enters the old and the new plan names in the specified text fields. There are also Done, Cancel, and Help buttons.

9. Personnel Overlay edit popup dialog box

Figure 25 shows the Personnel Overlay dialog box. There are icon type drawn buttons representing various personnel related information; Labor resources, Prisoners of war, Personnel files, Strength status, and Morale. Below these drawn buttons are four arrow buttons used to set the orientation of the inserted Information Anchor. There are also Done and Cancel buttons. The drawn button types may increase in number and design in future
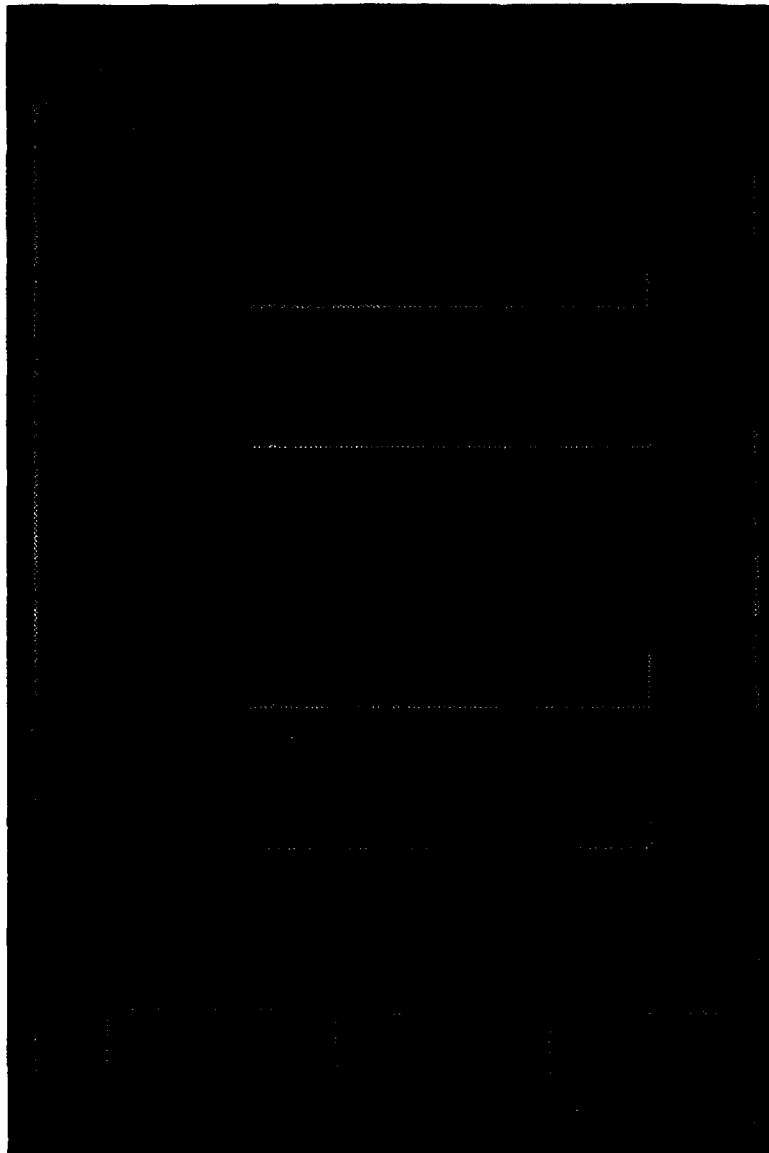
Figure 22 - Time Popup Dialog Box
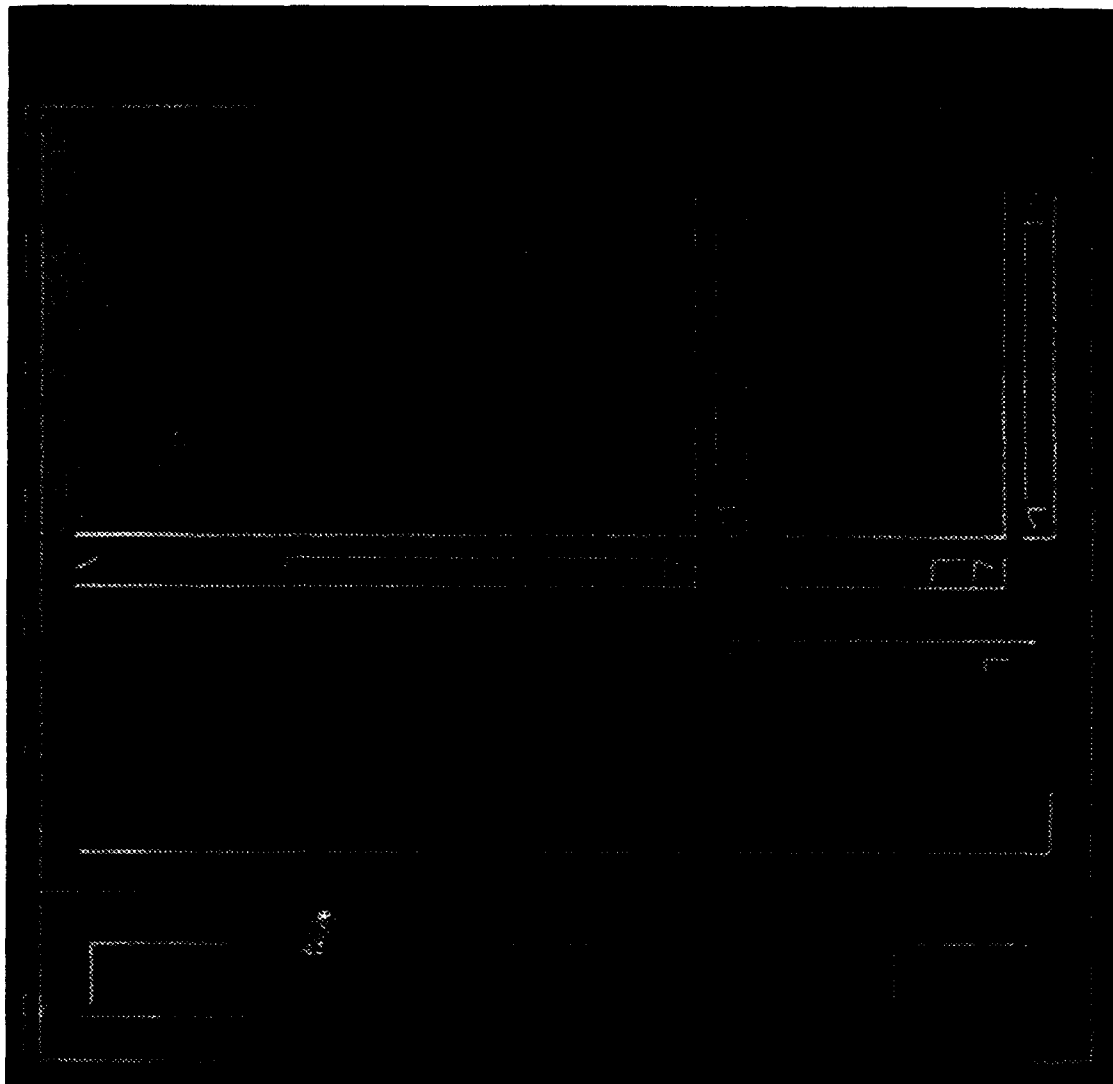
Figure 23 - Plan Pulldown Menu Option Open Popup Dialog Box
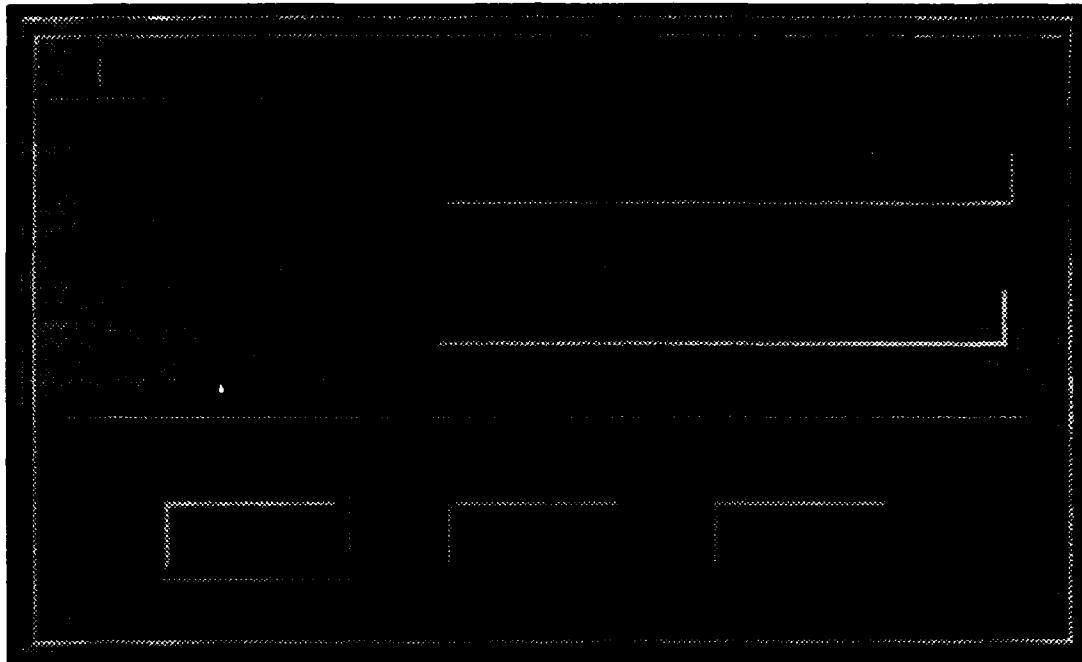
Figure 24 - Plan Pulldown Menu Option Save As Popup Dialog Box

GUI designs of the model. Let's say the user wants to insert a prisoners of war camp into the Personnel Overlay. He selects the Prisoners of war drawn button. When he presses that button another dialog box, New Anchor Orientation, is initiated.

10. New Anchor Orientation popup dialog box

This dialog box is displayed in Figure 26. There are three sliders, namely X, Y, Z. The user may user both the mouse left and middle buttons or the sliders to move to the desired coordinates in the 3D terrain. When he decides that the location is appropriate, he presses Ok button. The Auto Anchor Edit popup dialog box, explained in the next section, pops up. The user may use also the up and down arrow buttons on the keyboard to move to the desired position within one meter resolution. The mouse cursor should reside on the slider depending on which direction user wants to move.

11. Auto Anchor Editor popup dialog box

This dialog is initiated when the user presses the Done button in the New Anchor Orientation dialog box. This dialog box is shown in Figure 27 and is the same dialog box which pops up when the user selects Anchor option from the Edit pulldown menu. The Type, Orientation, X, Y, Z coordinates text fields are automatically filled by the system depending on which overlay edit tool the user has selected. The user only needs to enter the Name of the Information Anchor and the related hypermedia, namely the related Video file, Graphic file, Audio file, and Text file. Then he presses the Save push button and all the entered information is saved into the hyper-system database. The Information Anchor is displayed only if the edited type of overlay is displayed. There are Revert, Close, New Anchor, and Add Anchor push buttons in the dialog box. The user unmanages this dialog box by selecting the Close button.

12. Intelligence Overlay Edit popup dialog box

Figure 28 shows the Intelligence Overlay Edit dialog box. There are five drawn buttons to specify various intelligence information types that may be used by the staff and

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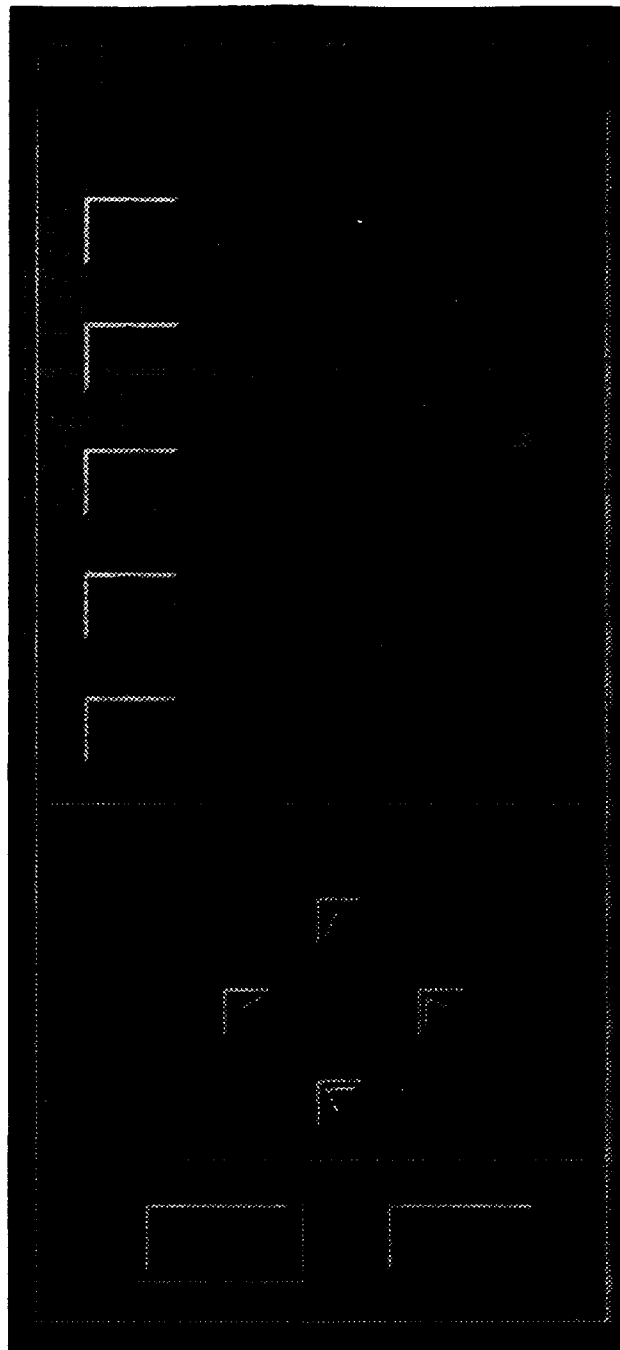
Figure 25 - Edit Pulldown Menu Option Overlay - Personnel Popup Dialog Box
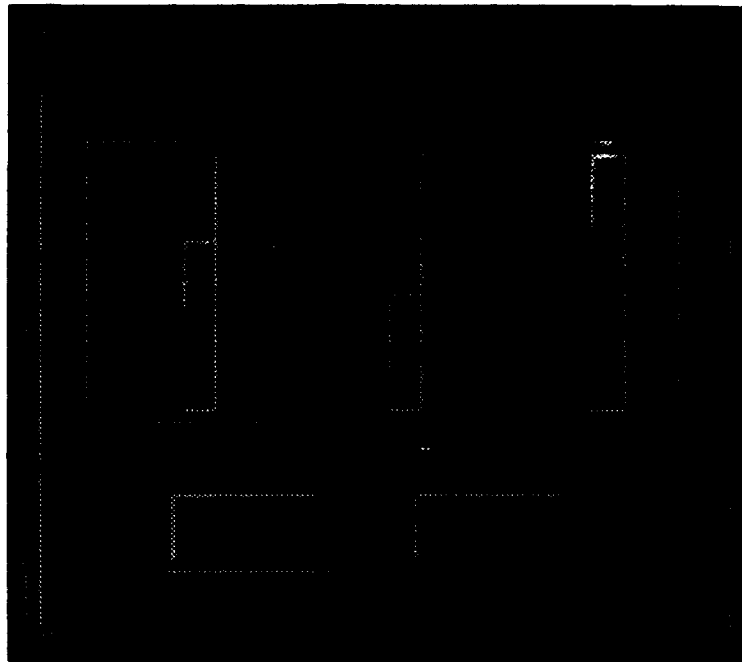
Figure 26 - NewAnchor Orientation Dialog Box
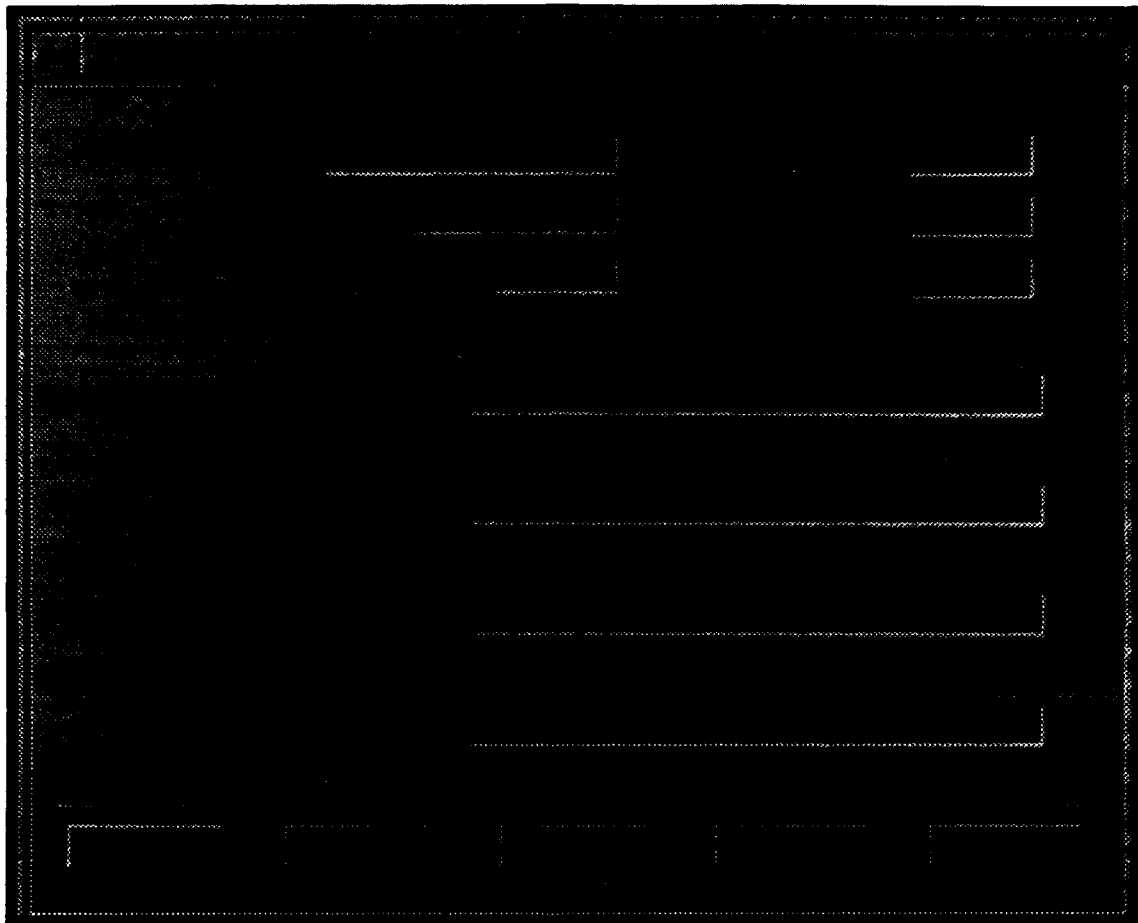
Figure 27 - Edit Pulldown Menu Option Anchor Popup Dialog Box

the commander. They are displayed in red color which represent the enemy. There are buttons for Tank, Infantry, Artillery, Motorized, and Special Forces units information types. There are also orientation arrow buttons, as well as Done and Cancel buttons. This dialog box and all other Overlay Edit popup dialog boxes work the same way as the Personnel Overlay Edit tool explained previously.

13. Operations Overlay Edit popup dialog box

This dialog box is displayed in Figure 29. It has the same type of drawn buttons defined in the Intelligence Overlay Edit dialog box, except these are blue colored, representing the friendly forces.

14. Logistics Overlay Edit popup dialog box

As shown in Figure 30, this dialog box has six drawn buttons representing various logistic related information, namely Class1-food supply, Class2-clothing supply, Class3-petroleum supply Class4-barrier materials, Clas5-ammunition supply, and Maintenance. The working principles for this dialog are the same as the above described Overlay Edit dialog boxes.

15. Civil Affairs Overlay Edit popup dialog box

This dialog box is displayed in Figure 31. There are two drawn buttons displayed on this dialog: Civil affairs and Psychological Ops buttons. This dialog is used to insert any Civil population related information and activities.

16. Order of Battle Editor popup dialog box

This dialog box is shown in Figure 32. It has six text fields and four push buttons. The text fields are for Identifier, Recipient, Action Constraints, Target-Location, and Follow-up. The Identifier text field includes the information about the command which issues the order. Recipient is the unit which receives the Order of Battle. Action Constraints contains information about time or action constraints related to the action defined in the Action text field. Follow-up contains information about what will be done after the action
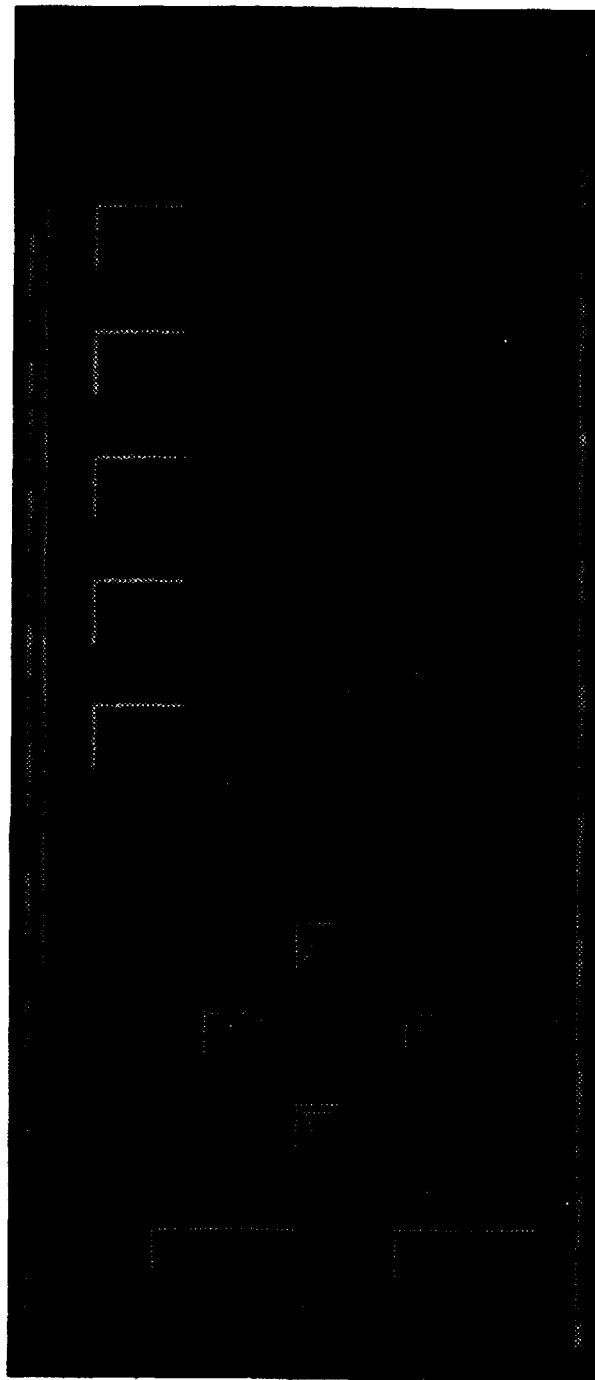
Figure 28 - Edit Pulldown Menu Option Overlay - Intelligence Popup Dialog Box
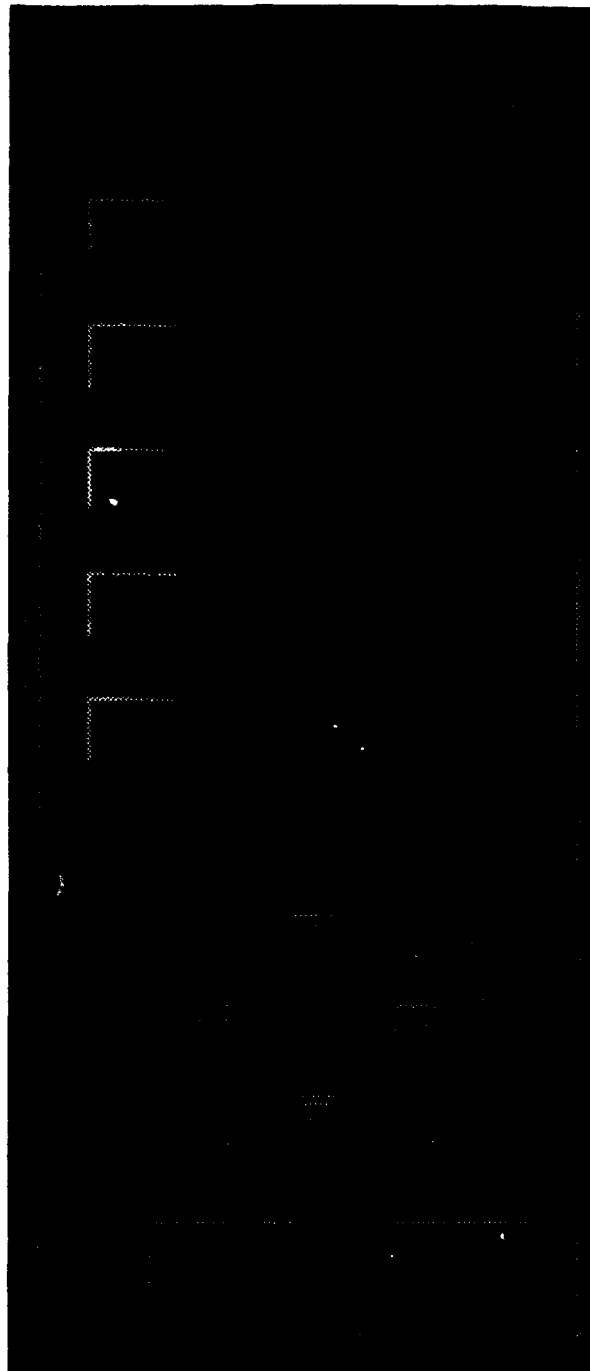
Figure 29 - Edit Pulldown Menu Option Overlay - Operations Popup Dialog Box
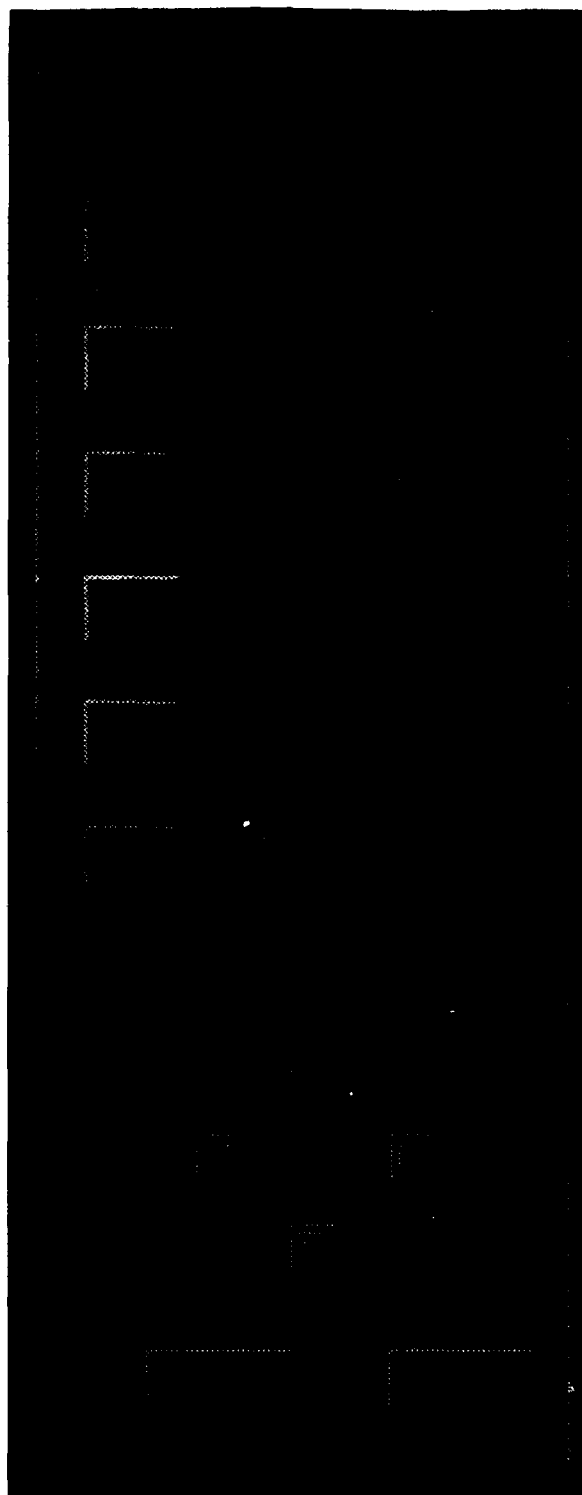
Figure 30 - Edit Pulldown Menu Option Overlay - Logistics Popup Dialog Box
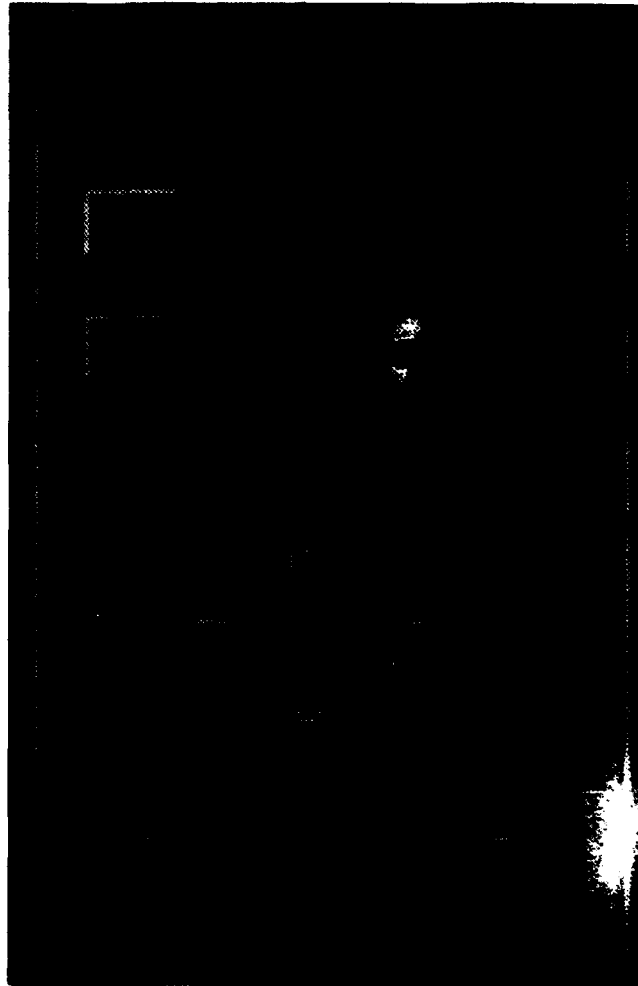
Figure 31 - Edit Pulldown Menu Option Overlay - Civil Popup Dialog Box

specified in the Action text field is executed. The user saves and sends the Order of Battle by pressing the Save and Send buttons. He can write a new order without closing the dialog box by pressing New Order button which clears the information written in the text fields of the old Order of Battle. He closes the dialog box by pressing the Close button.

17. Anchor Information Display popup dialog box

This dialog is displayed in Figure 33. This dialog box is invoked by the user by selecting the Anchors option from the display pulldown menu. There are five options:

- Personnel: When selected the invoked Anchor Information Display dialog Information Anchor selection list displays the Information Anchors linked to the Personnel Overlay.
- Intelligence: The Information Anchors list displays Information Anchors linked to the Intelligence Overlay.
- Operations: The Information Anchors list displays Information Anchors linked to the Operations Overlay.
- Logistics: The Information Anchors list displays Information Anchors linked to the Logistics Overlay.
- Civil: The Information Anchors list displays Information Anchors linked to the Civil Affairs Overlay.
- All: The Information Anchors list displays all available Information Anchors related to all types of overlays.

There are five text fields in the Anchor Information Display dialog box all of which provide information about the selected Information Anchor:

- Anchor Name: Displays the name.
- Anchor Type: Displays the type.
- X: Displays the X coordinate.
- Y: Displays the Y coordinate.
- Z: Displays the Z coordinate.

There is an Information Anchor selection list. This list displays the Information Anchors related to the selected overlay type. Beneath this list there are four push buttons:

- Jump: The user first selects one of the displayed Information Anchors and then, by pressing that button, he selects the Information Anchor of interest. All the text fields are filled with the selected Information Anchor's related information. The drawn buttons are highlighted depending to the multimedia information linked to that Information Anchor. The user is transported to the location of the selected Information Anchor in the virtual world.

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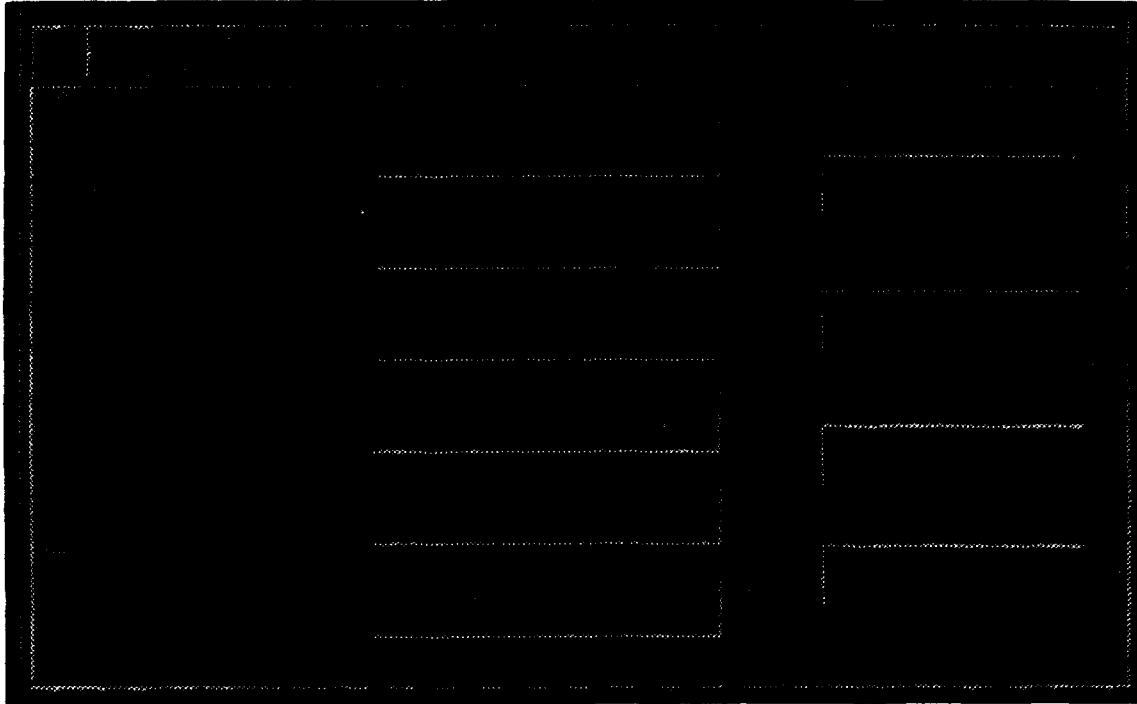
Figure 32 - Edit Pulldown Menu Option Order of Battle Popup Dialog Box
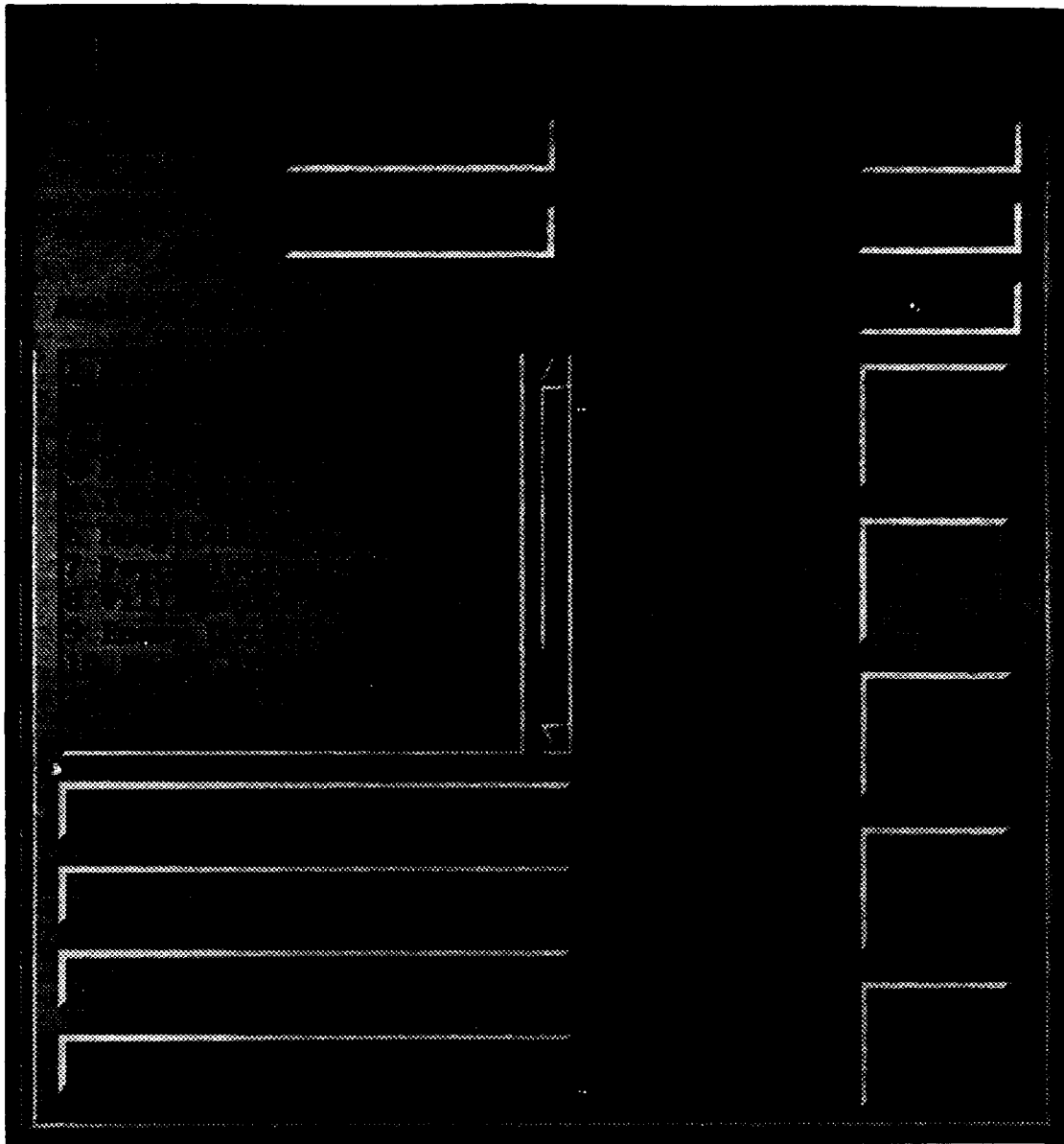
Figure 33 - Anchor Information Dispaly Popup Dialog Box

- Delete: This button provides the user with the option to delete the selected Information Anchor from the hyper-system database and related overlay.
- Done: Closes the Anchor Information Display popup dialog box.
- Help: Gives information on how this dialog should be used.

There are five drawn buttons on the right side of the dialog box:

- Video: If pressed when highlighted (active) invokes the Video Files popup dialog box.
- Audio: If pressed when highlighted (active) invokes the Audio Files popup dialog box.
- Graphics: If pressed when highlighted (active) invokes the Graphics Files popup dialog box.
- Text: If pressed when highlighted (active) invokes the Text Files popup dialog box.
- Back: When pressed the user jumps to the Information Anchor last visited before the current one. This provides the user to keep a history of the selected anchors and travel between them, and allows him to back out through previously visited anchors in reverse order.

The user selects one of the Information Anchor names displayed in the selection list. Then the coordinates, name and type of this anchor are filled into their specified text fields. Also the drawn buttons get a highlighted (active) or not highlighted (inactive) state depending on whether there is related multimedia information attached to that specific anchor. For example, if the selected Information Anchor has video and text information attached to it., only the Video, Text, and Back drawn buttons will be highlighted. The user has a choice of selecting what information he wants to see. Thus he invokes other dialog boxes explained in the following sections:

- Audio Files popup dialog box
- Video Files popup dialog box
- Graphic Files popup dialog box
- Text Files popup dialog box

18. Video Files popup dialog box

This dialog box is shown in Figure 34. It is invoked when the user presses the active Video button in the Anchor Information dialog box. A selection list of the available

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video files, a text field displaying the selected video file, a screen, and two sliders (for contrast and for voice) are displayed. There are five video control button under the screen:

- Play: Starts playing the video file.
- Backward rewind.
- Forward rewind.
- Pause button.
- Stop button.
- Enlarge button: This button provides full screen display of the selected and playing video.

There are four push buttons:

- Delete: Deletes the selected video file from the hyper-system database and from the related Information Anchor.
- Add pops up a dialog box to enter a new video file name. Thus the user can link different video files into the database of the selected Information Anchor.
- Done: Closes the Video Files dialog box.
- Help: Provides help to explain how to use the interface of that dialog box.

19. Audio Files popup dialog box

The audio files popup dialog box shown in Figure 35, is invoked by pressing the highlighted Audio drawn button in Anchor Information Display dialog box. There is a selection list of available audio files, a text field displaying the selected audio file and a slider for the volume. Five buttons to control the playing of the audio file:

- Play
- Back rewind
- Forward rewind
- Pause
- Stop

There are four other push buttons:

- Delete: Removes the selected audio file from the hyper-system database.
- Add: Invokes another dialog box to enter a new audio file name.
- Done: Closes the dialog box.
- Help: Provides help to explain how to use the interface of that dialog box.

20. Graphic Files popup dialog box

Figure 36 displays this dialog box. There is a selection list of available graphic files linked to the selected Information Anchor. It is invoked by pressing the highlighted
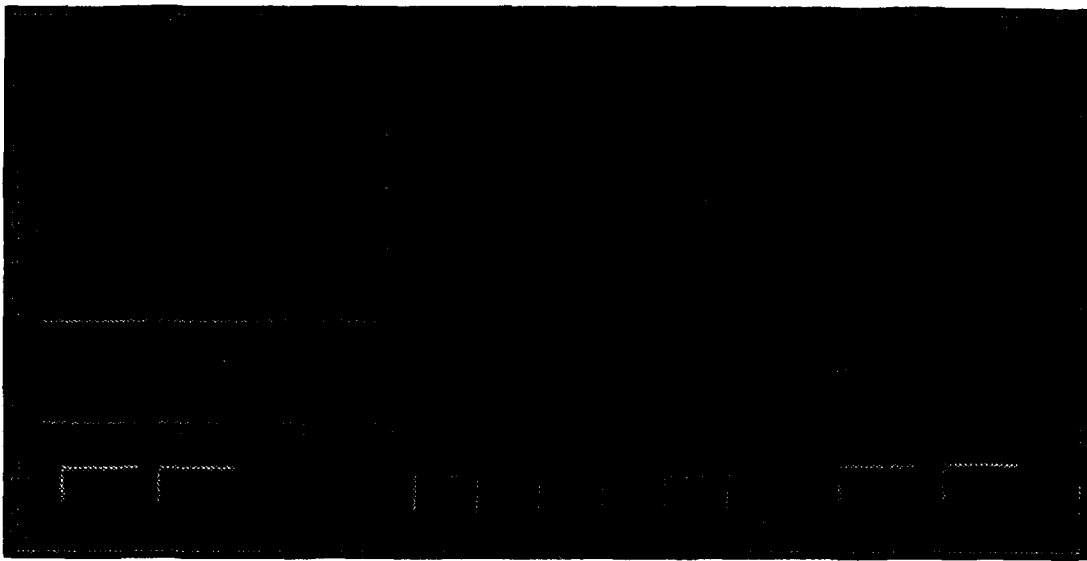
Figure 34 - Video Files Popup Dialog Box
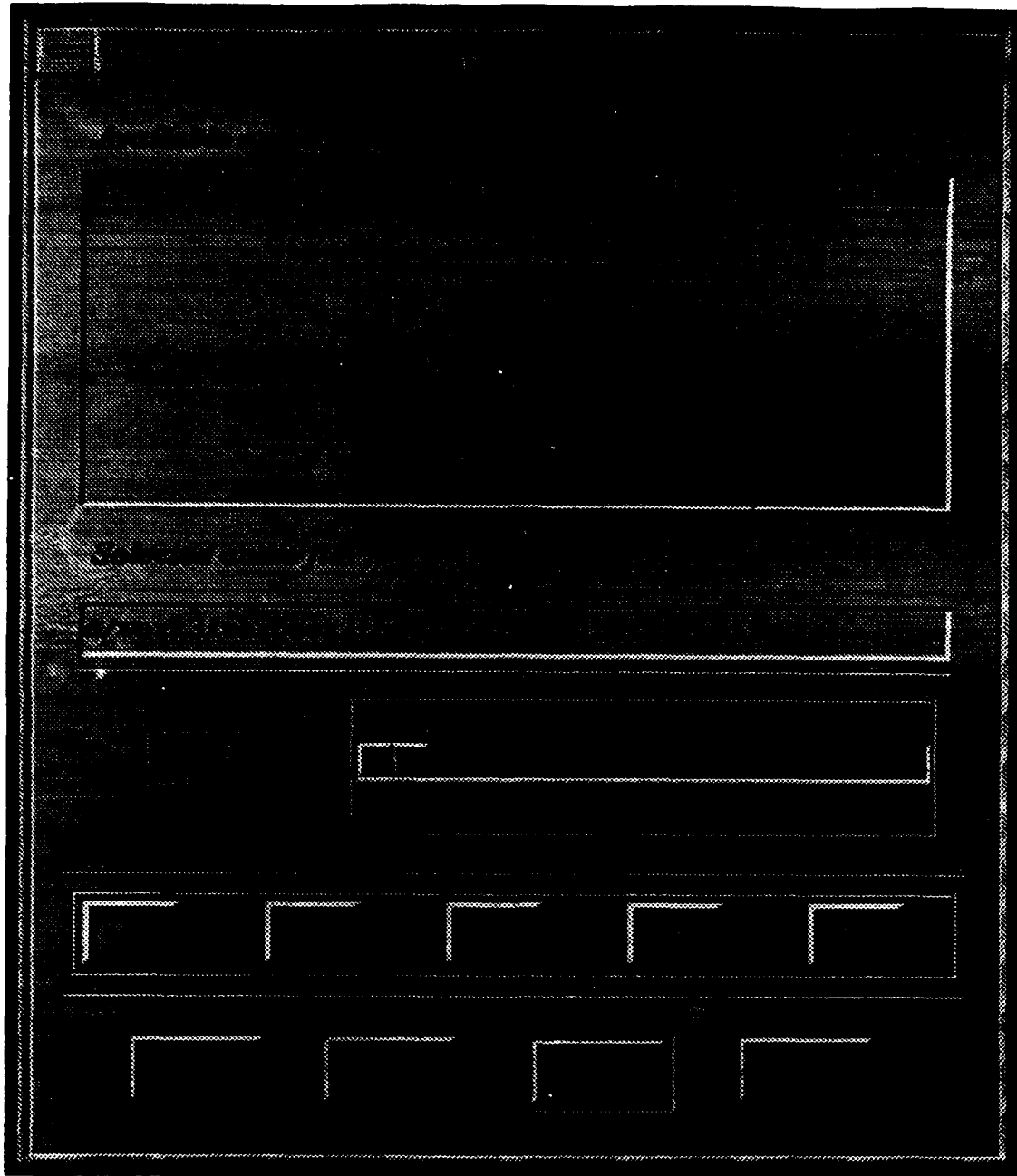
Figure 35 - Audio Files Popup Dialog Box

Graphic drawn button in Anchor Information Display dialog box. There are five push buttons on the right side of the dialog box:

- Show: Displays the selected graphic file in a separate popup window. When pressed a second time, it closes the graphic file being displayed.
- Delete: Removes the selected graphic file from the hyper-system database and selected Information anchor.
- Add: Pops up a new dialog asking for a new graphic file name to be inserted into the hyper-system database linked to the selected Information Anchor.
- Done: Closes the dialog box.
- Help: Gives information on how to use the displayed dialog box.

21. Text Files popup dialog box

This dialog is displayed in Figure 37. It is invoked by pressing the Text drawn button from the Anchor Information Display popup dialog box. It has the same features as the Graphic Files popup dialog box.

22. Weather popup dialog box

This dialog box is shown in Figure 38. It is invoked when the user selects the Weather option from Display pulldown menu. This dialog box displays all the information entered by the commander or Intelligence officer during the scenario creating process.

23. View popup dialog box

Figure 39 shows the View popup dialog box which can be invoked from the Display pulldown menu. ng this dialog box, the user can select whether the move mode is Drive or Fly. He can adjust the moving speed. He can set the distance from which the Information Anchors are made visible. There are X, Y, Z orientation slide bars. These show the coordinates of the user while he is navigating through the 3D virtual sand table. There are also four drawn buttons:

- Video files: Invokes a dialog box from which the user may search and retrieve any type of video information located in the hyper-system database.
- Audio files: Invokes a dialog box from which the user may search and retrieve any type of audio information located in the hyper-system database.
- Graphics files: Invokes a dialog box from which the user may search and retrieve any type of graphic information located in the hyper-system database.
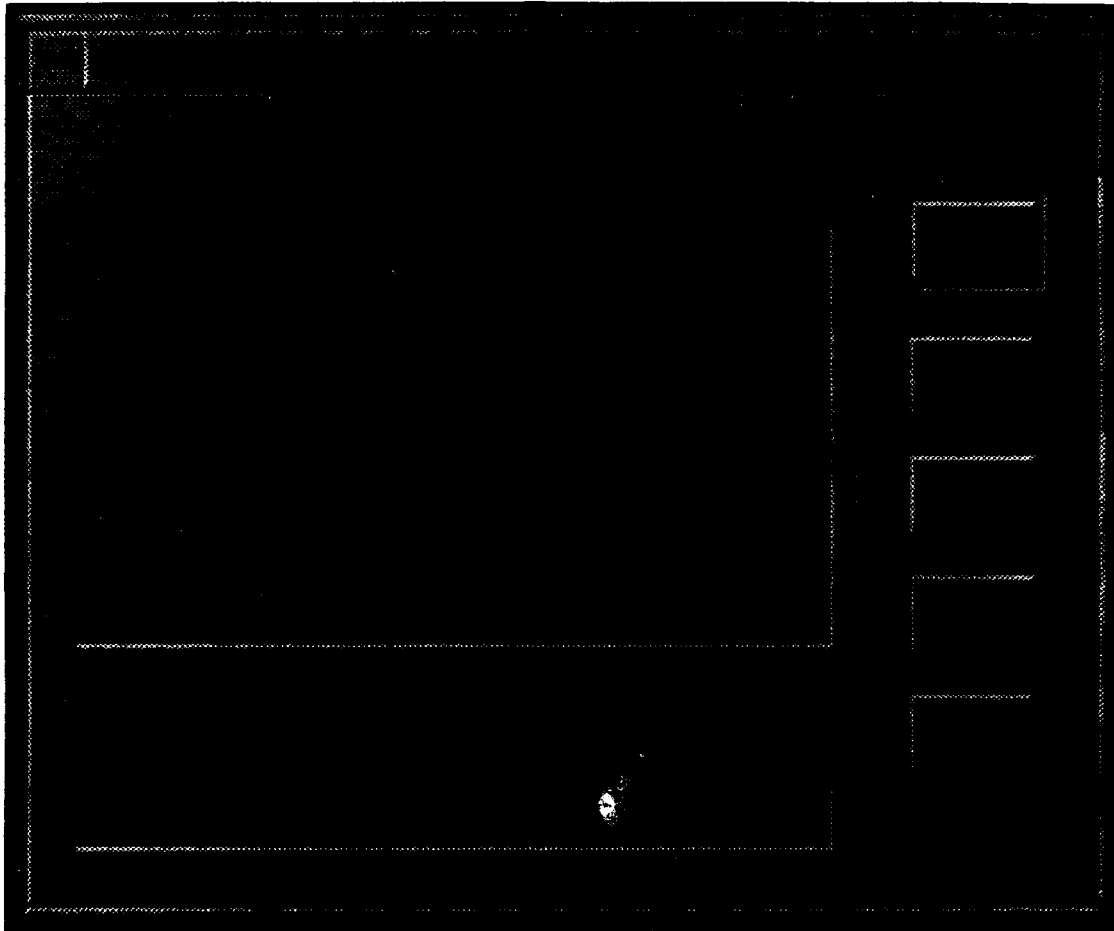
Figure 36 - Graphics Files Popup Dialog Box
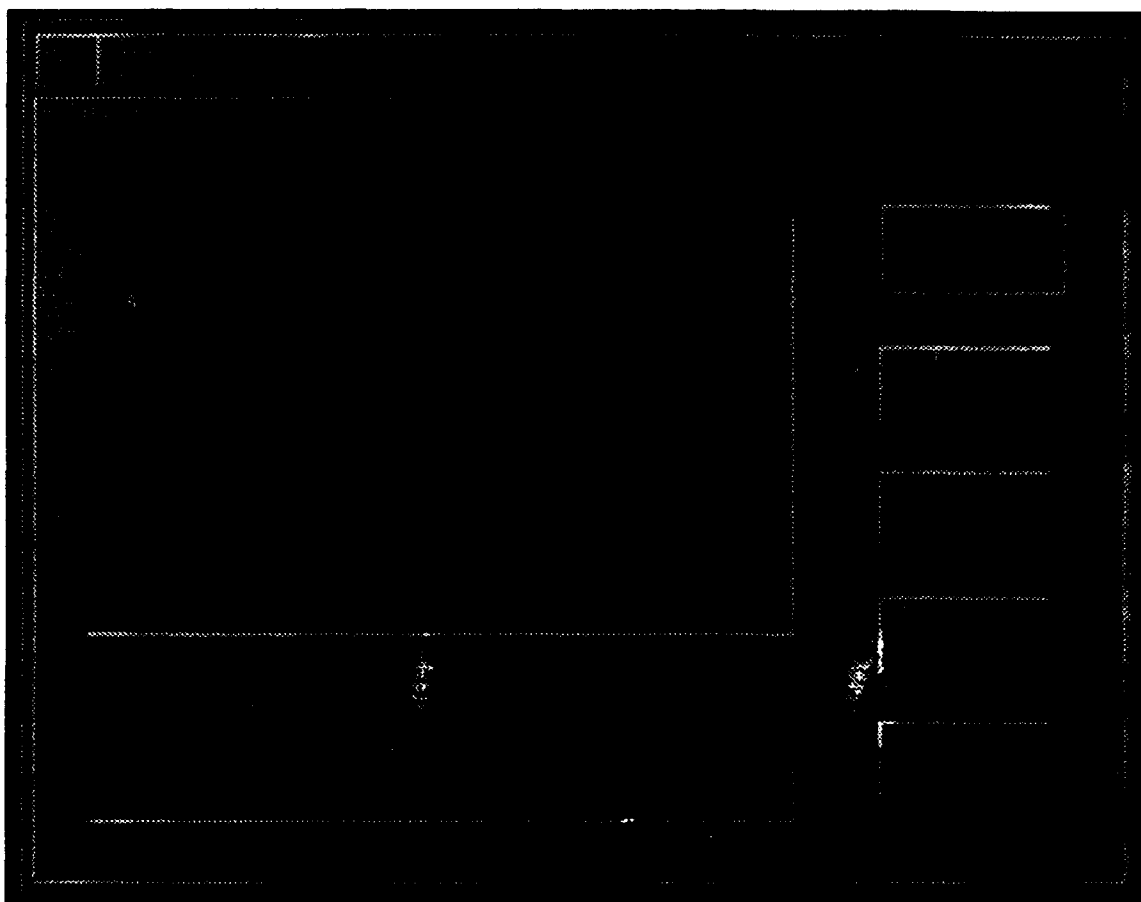
Figure 37 - Text Files Popup Dialog Box
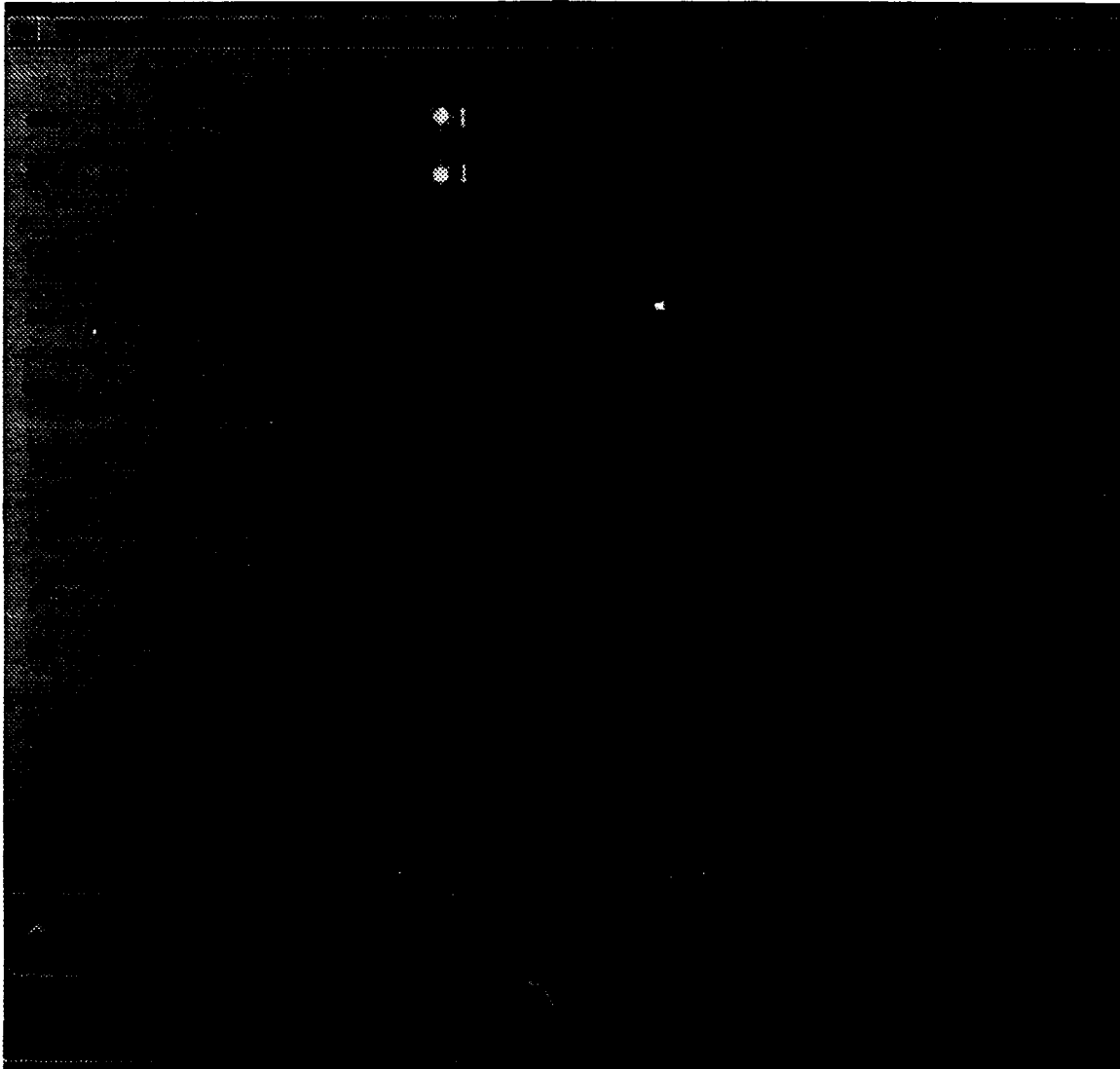
Figure 38 - Display Pulldown Menu Option Weather Popup Dialog Box

Figure 39 - Display Pulldown Menu Option View Popup Dialog Box

- Text files: Invokes a dialog box from which the user may search and retrieve any type of text information located in the hyper-system database.

There are also Done, Cancel, and Help push buttons, which are self explanatory.

24. View Video Files popup dialog box

This dialog box is displayed in Figure 40. The user may select the area of interest, namely Personnel, Intelligence, Operations, Logistics, Civil or All, by pressing the related radio button located on the left side of the dialog box. The selection list is filled with the video file names related to the selected area of interest. The rest of the GUI is the same as the Video Files popup dialog box explained above.

25. Audio Files popup dialog box

Figure 41 shows that dialog box. This has the same radio buttons as the Video Files popup dialog box to select the area of interest. The rest of the GUI is the same as explained in Text Files popup dialog box.

26. View Graphics Files popup dialog box

Figure 42 shows this dialog box. It has radio buttons to select the area of interest, and the same GUI as the Graphic Files popup dialog box.

27. View Text Files popup dialog box

Figure 43 shows this dialog box. It has radio buttons to select the area of interest, and the same GUI as the Text Files popup dialog box.
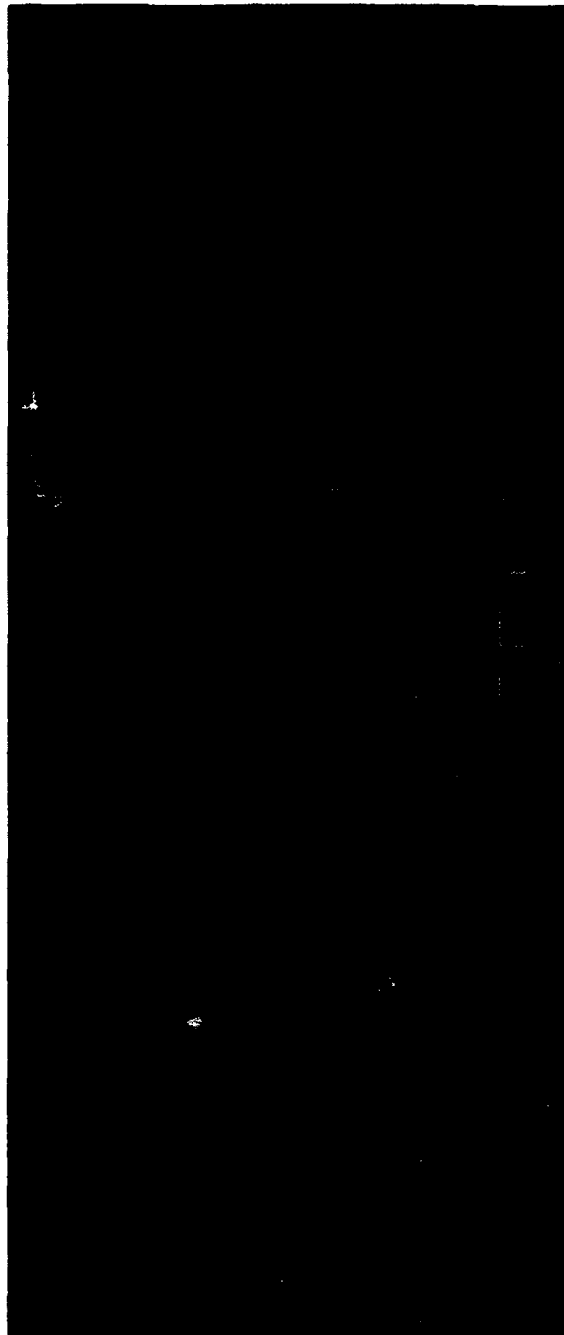
Figure 40 - View Video Files Popup Dialog Box
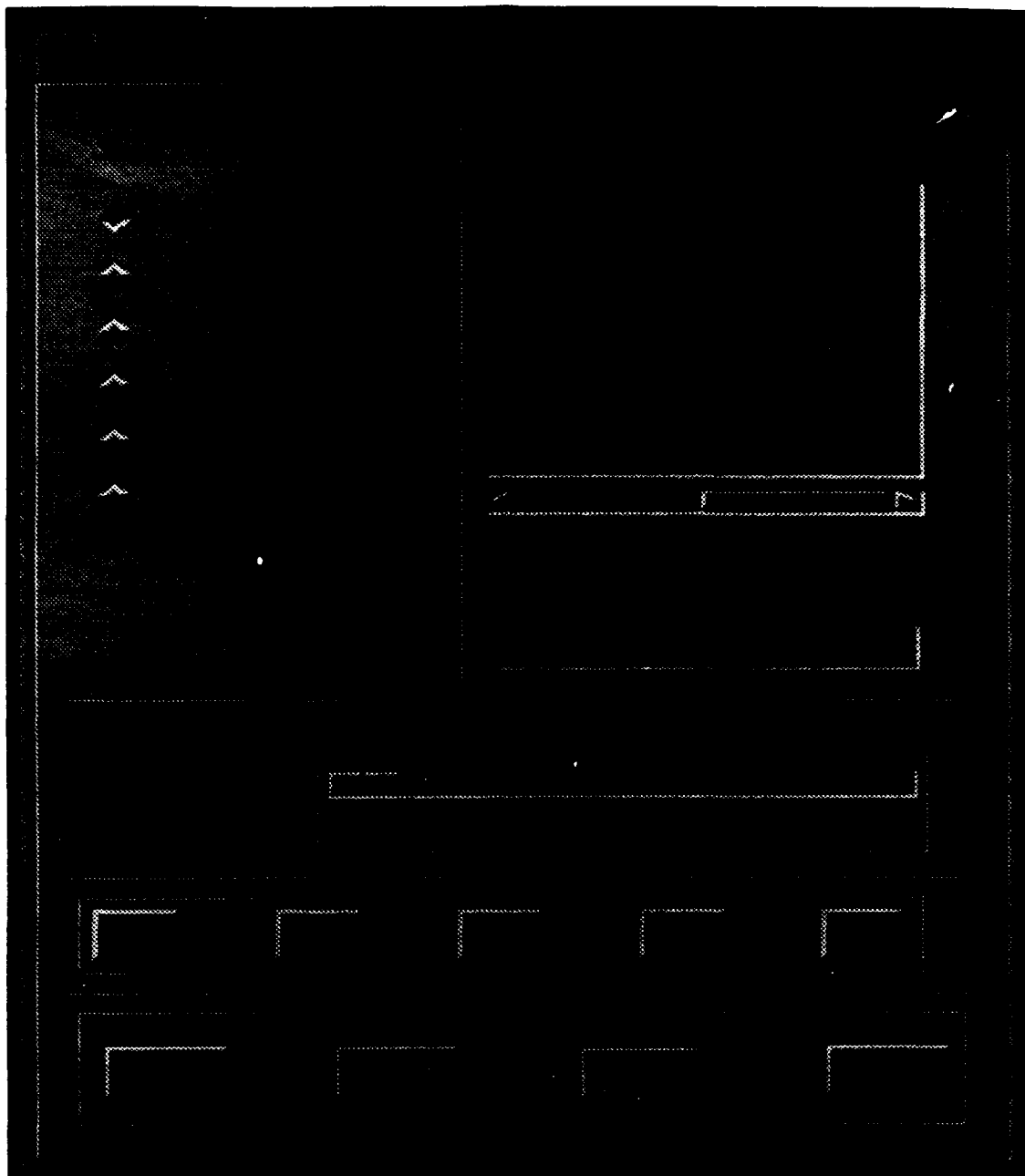
Figure 41 - View Audio Files Popup Dialog Box
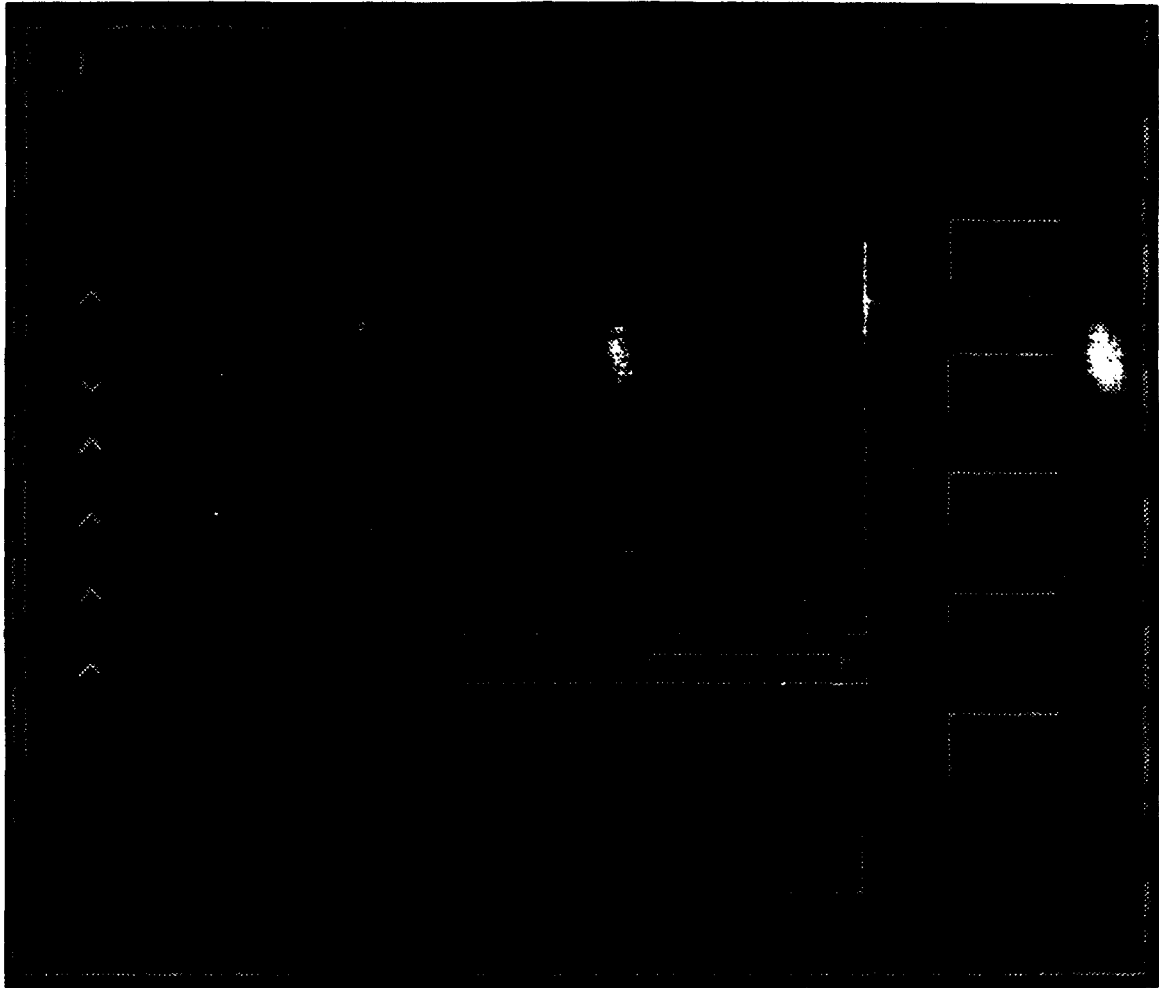
Figure 42 - View Graphics Files Popup Dialog Box
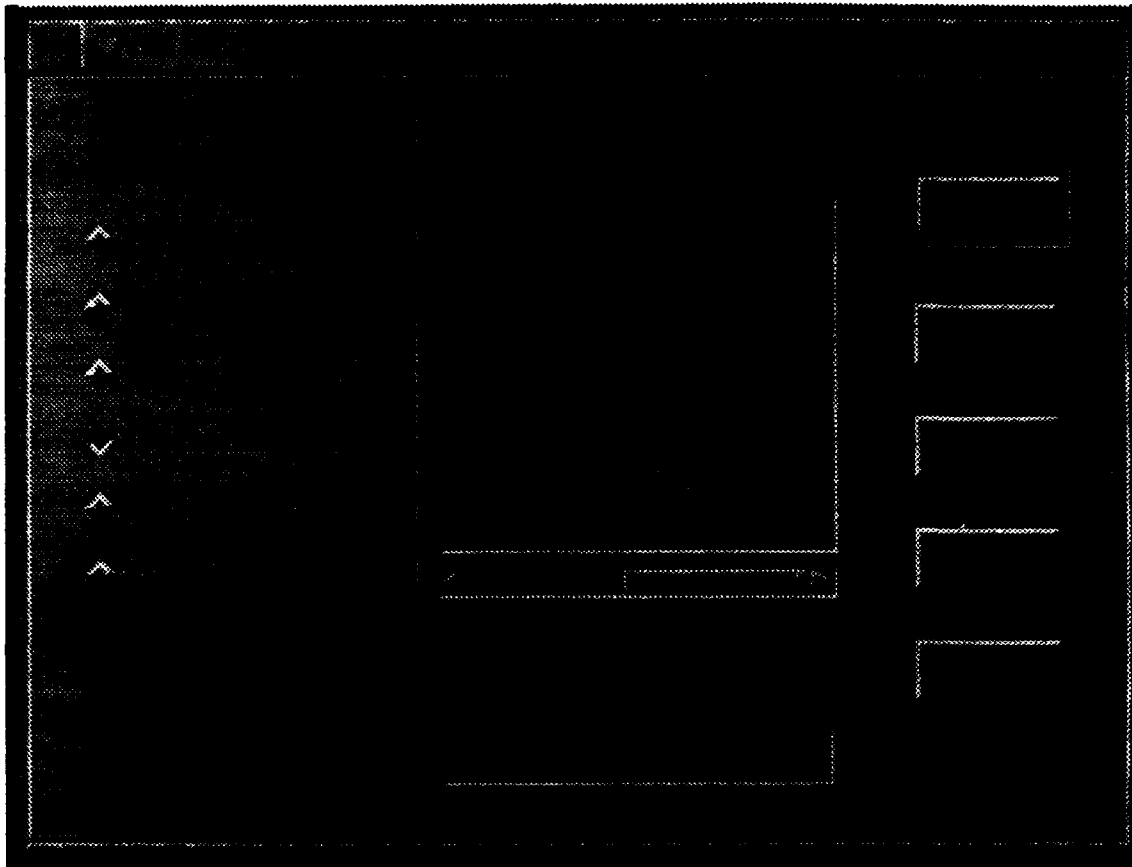
Figure 43 - View Text Files Popup Dialog Box

V. AUTOMATION SUPPORT ELEMENTS

For the moment ATOC³IPT does not support any networking capability except minimal DIS to a sound server. The goal of ATOC³IPT is to supply hypermedia and tactical information to the staff executing the operations in various echelons of the Army. The ATOC³IPT is considered to be operable with Defense Advanced Research Projects Agency(DARPA) Simulation Network (SIMNET) and the follow-on Distributed Interactive Simulation(DIS) networking standard. Also some appropriate security measures must be considered during the networking implementation of such a model.

A. COMMUNICATIONS NETWORK

The majority of the current virtual environments are little more than sophisticated single system or low connectivity (one or two workstations) "fly-through" systems, direct descendants of the traditional flight simulator. As virtual environment-based battle simulators evolve, there is a significant demand for more advanced information integration and higher connectivity. As we move from 250 players to 10,000 player systems, the technical issues of distributed world models, model consistency and real-time scene management become significantly harder.

Virtual environments communication software passes changes in the world model to other players on the network and allows the entry of previously undescribed players into the system. When we move into a networked environment, we need to consider issues of database consistency more closely than we do in the single workstation world. We need a standard message protocol between workstations that allows communicating changes to the world. For small systems, we need to make sure that all players on the network have the same world models and descriptions as time moves forward in the virtual environment "action".

The DARPA-funded SIMNET project was the first working virtual environment with a substantial population. Over 200 simulators with 4-person crews can be connected, using

both local and long haul networks: Each crew is completely immersed in the training scenario and can see and interact with 30 or more other vehicles at a given time. Simulator vehicles include tanks, personnel carriers, fixed wing aircraft, and helicopters. Opposing forces may be manned simulators or semiautonomous "virtual enemies" whose only existence is in software. The SIMNET training site at Ft.Knox, Kentucky (and its twins at several other locations in the United States and Germany) are now in active use, helping NATO's armor units to improve their team performance. The use of low-cost "video game" technology has enabled the construction by DARPA of the first large-scale team training simulation system. This system is now having a profound impact on the entire Western military training establishment [Moshell93].

The forces driving the military community toward networked simulation (as an alternative to field training) are primarily economic and political in nature, but there are also technological factors involved. It is sometimes impossible to conduct large military operations in densely populated areas. Transportation, fuel, ammunition, and maintenance costs for such operations or exercises are far more expensive than simulation. Security and safety considerations also prevent full utilization of military equipment.

1. Networking System Design Considerations

The most important aspect of the networking environment to be used by the ATOC^{3}IPT is its performance in transmitting the hypermedia database, namely video, audio, graphics, and text. Many researchers have explored multimedia collaboration over local area networks such as Ethernet. And research on Internet shows great promise. Audio flows well through multicast backbone embedded within the Internet; video rates are restricted to a frame every few seconds [Elliot93]. Multimedia networking works well if the underlying network can provide two crucial services that most packet networks do not yet provide: packet multicasting and bandwidth reservation. The easy blend of video, audio, and shared multimedia database and workspace is made possible by a long-haul, packet-switched network similar to that used for that widely known worldwide network,

"the" Internet. Packet networks have the cardinal virtue that they can transmit all sort of data - video, audio, or whatever - in any mixture. However, conventional packet-switched networks have a number of problems which make reliable transmission of real-time data, such as voice and video, nearly impossible:

- Packets: The network may deliver packets out of order, drop packets if the load grows too great, or deliver the same packet multiple times. These factors play havoc with streams of real-time data.
- Lack of Bandwidth Reservation: As packet networks are typically designed to service packets on a first-come, first-served basis, there can be wild swings in the number of packets introduced into a network. Such networks can't guarantee any particular throughput rate.
- Lack of Multicasting: The other major problem with traditional packet networks is that they transmit packets point-to-point. To transmit the same data to n receivers requires n packets. For data rates required for audio/video, such replication is out of the question. The solution is multicasting, in which a single packet of data, such as video update, can be sent to multiple recipients without undue replication. Thus any number of sites can receive a media stream without increasing its bandwidth.

It appears, therefore, that transmission of real-time multimedia requires something other than a traditional packet network. In order to prevent unnecessary expenditures the best solution is to base the ATOC^{3}IPT network on already existing networks and protocols.

Defense Simulation Internet (DSI), is a re atvely new worldwide network created by Bolt Beranek and Newman (BBN) unde ARPA sponsorship for packetized transmission of real-time data. Like many conventional packet networks, it runs mainly over optical fiber terrestrial trunk lines at T1 speeds, i.e., 1.54 megabits/second. Since the DSI was originally designed for worldwide, many-machine simulations and built to transmit the real-time data streams needed to coordinate distributed simulators, it provides the bandwidth reservation and multicasting that make multimedia transmission feasible.

Data packets within media streams are currently sent in a very simple, ad hoc format. Video (heavily compressed) currently runs at 112 kilobits/second, so one video stream occupies roughly 7% of the DSI's total bandwidth. An uncompressed audio stream,

at about 64 kilobits/sec, occupies another 4% of the total bandwidth [Elliot93]. Currently the best solution is using DSI network in the ATOC^{3}IPT for its database communication.

ATOC^{3}IPT suggests the combination of Distributed Interactive Simulation (DIS) and Distributed Artificial Intelligence (DAI). DIS is an architecture for building large-scale simulation models from a set of independent simulator nodes. The simulator nodes are linked by a network and communicate via a common network protocol. In DIS, the simulator nodes each independently simulate the activities of one or more entities in the simulated system and report their attributes and actions of interest to other simulator nodes via the network in real time. A DIS system, of which the DARPA/US Army SIMNET system is the archetype, depends on two points of agreement between the networked simulators. The first is the "shared field", or simulated environment, which usually takes the form of a terrain database. The second required point of agreement is the network protocol. A DIS protocol specifies the various types and formats of network packets which the simulator nodes will exchange to support the simulation model, the precise circumstances under which each packet type should be sent by a simulator node, and the interpretation that should be performed when each packet type is received [Brackle93].

DAI is an approach for representing, modeling and executing behavior of simulated tactical units, battlefield, and individual combatants in a complex combat planning and training simulator [Wittig93]. For Combat Training Simulators (CTS), Artificial Intelligence (AI) and Distributed AI (DAI) appear readily suitable for representing and controlling the behavior of individual agents as well as their superior tactical units. The Artificial Intelligence support to the ATOC^{3}IPT is examined in the following sections.

When we consider a TOC one very important issue is the dissemination of the orders related to an operation. As an example we will discuss in detail how the battle orders the commanders are giving to battalions or units of the simulated "opposing" side in a

complex scenario can be distributed c vn the hierarchical levels to the individual vehicles and their troops.

The principle of the ATOC^{3}IPT is that the Commander sets up a scenario in which the type of operation, terrain of operation, weather conditions, friendly forces, and opposing forces are specified. The commander gives his units a mission by issuing an order of battle which then must be carried out by his staff and subordinates in accordance with the development of the tactical relevant situation in the battlefield area. The opposing forces may be autonomous (sometimes called "semi-autonomous"), free to intelligently coordinate their activities depending on the tactical situation.

Military orders are in principle pre-defined; only a relatively small number exists. However, they need to be given for each level within the brigade, battalion, or company. This instantiation, i.e. applying a general concept to a specific situation with all its details, can follow some general procedures as, for example, determining all the waypoints for each vehicle in a unit.

The commander examining the situation overlays developed by his staff gives an order of battle to one of his battalions. The ATOC^{3}IPT suggests a decomposition of the order of battle into smaller, more focused parts that are executable by the recipients. As described previously, Figure 32 shows how a general decomposition format may look like. For example, a battalion receives an order "Capture and hold Hill#XXX". The battalion commander then has to derive specific orders for his companies, and company commanders receiving their missions will have to do so for their platoons. These specific orders involve definition of the routes from the current position, setting up of event-lines such, as the Line of Deployment, etc. Each platoon leader then has to translate his command into smaller parts for his vehicles and troops. The proposed general format to be used for issuing orders from ATOC^{3}IPT is quite simple:

Order of Battle:

- Identifier: C-1
- Recipient: Battalion A

- Action: Capture
- Constraints: Reservation of fire
- Target-Location: Hill#XXX
- Follow-up: Hold

The important part of the order is the "Action" with its attached "Constraints". The assumed actions are limited in number. Each action has its own constraints. The "Follow-up" shows what to do when this order is carried out. It can be another order.

Typical actions considered in modeling the ATOC^{3}IPT include:

- March
- Reconnaissance
- Capture
- Hold
- Attack
- Gather
- Withdrawal
- Wait

After the order is executed by the lower unit, its results are reported back to ATOC^{3}IPT and will be displayed on the virtual terrain after being examined by related personnel. The timely reports forms the major emphasis of the networking of the ATOC^{3}IPT. Thus the commander always has the general overview of the battlefield on his ATOC^{3}IPT monitor. Also the staff officers are able to track any changes related to their situational plans and overlays.

It is assumed that the lower echelon units have either 3D display or 2D display workstations. When the plan is constructed by the upper headquarters, the staff officers and the commanders of the lower levels will be able to access the hypersystem database and retrieve and send required information and reports to the ATOC^{3}IPT hypersystem and expert system, which in harmony will filter the incoming data and display only the necessary information to the related personnel.

2. Security of the ATOC^{3}IPT network

Recent history has provided stark evidence of the intricacies and lethality of the modern, electronically supported battlefield and its unforgiving nature to those who have failed to prepare for it adequately. We must, therefore, insure the protection of the ATOC^{3}IPT networking system. In elementary and concise terms, the command and control and electronic warfare systems supporting them must be responsive, simple and secure. Implementing signal security (SIGSEC), electronic warfare (EW) techniques and lethal countermeasures can significantly enhance commander's ability to operate on today's battlefield in a coherent and effective manner [Rockwell86].

The ATOC^{3}IPT network security is suggested to consist of physical security, cryptosecurity, transmission security and emission security (see Figure 44). Physical security results from the application of physical safeguards for the ATOC^{3}IPT hypersystem database and the system as a whole from access and observation by unauthorized persons. These controls ensure that the ATOC^{3}IPT hypersystem database is modified, queried, used, stored, transported and destroyed in a secure manner. Cryptofacility approvals (CFAs) must be initially required for each unit networked to ATOC^{3}IPT, and cryptofacility inspections (CFIs) must be normally conducted periodically thereafter.

Cryptosecurity results from the application to radio communications, and proper use of, technically sound cryptosystems. Transmission security (TRANSEC) is designed to protect transmissions from hostile intercept and exploitation (other than cryptoanalysis). The two primarily techniques used in such systems are changing of radio frequencies and call signs. Authentication is another TRANSEC technique which is used to insure that only authorized senders are communicating with their intended receivers. As regards hostile electronic counter measures, use of this technique assists in preventing imitative communications deception. Other TRANSEC techniques for reducing the probability of hostile intercept and location of friendly emitters include the use of site masking, dummy antenna loads when testing, low power settings and directional antennas. Addi: ally, and
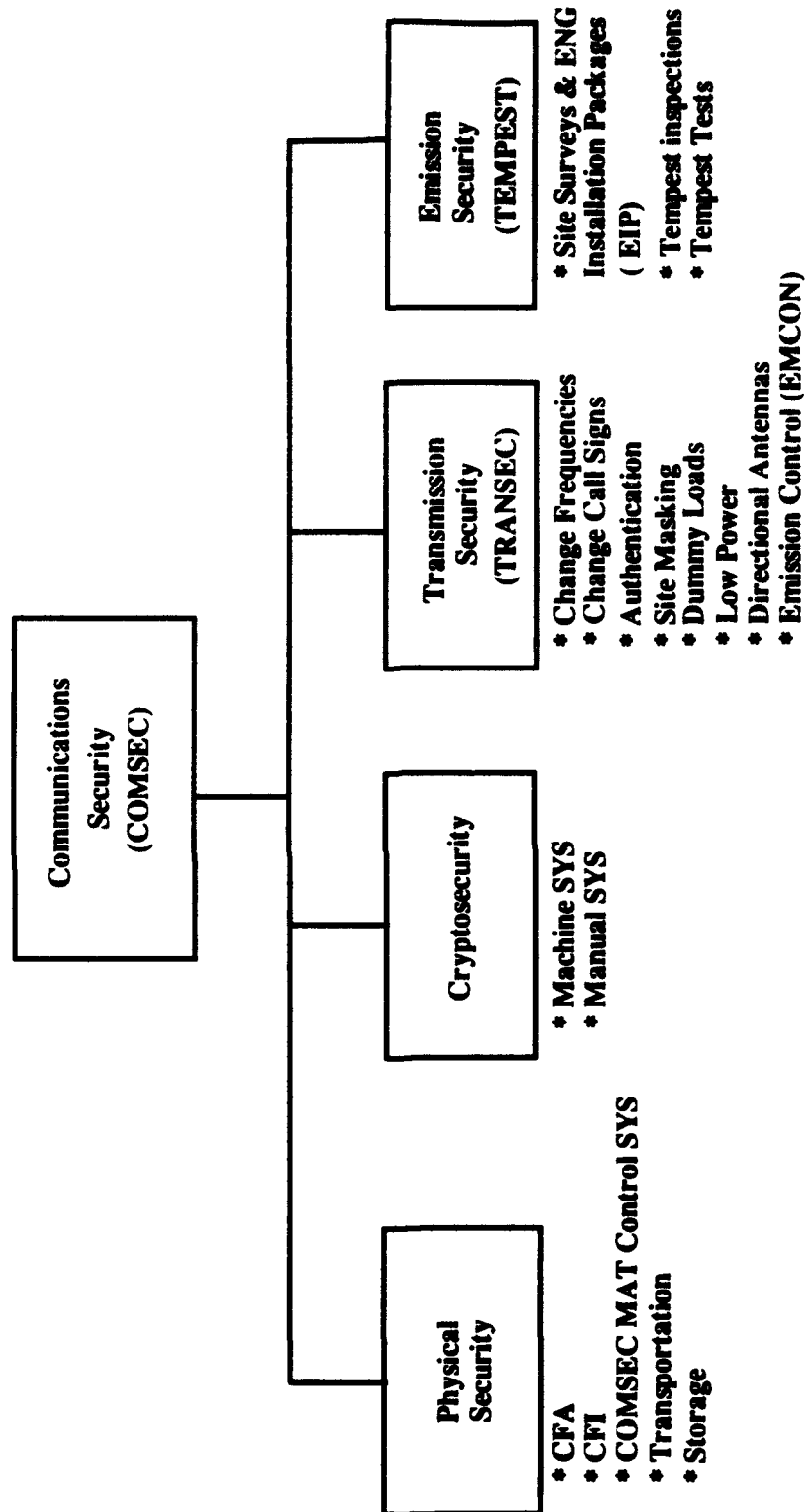
Figure 44 - ATOC³IPT Communications Security

perhaps even more importantly, the use of emission control (AMCON) requires that operators not use radios, or use only prescribed essential radios and then only for the shortest operating time.

The fourth component of COMSEC is emission security. The term usually associated with such an effort is "TEMPEST" which refers to investigations and studies of compromising and inadvertent emanations. The TEMPEST program consists basically of initial site surveys and reviews of engineering installation plans before a secure facility is constructed. After installation, inspections are performed periodically to determine the facility's conformity to established criteria.

B. DATABASE MANAGEMENT

1. Database Management System Design Considerations

The database management system of ATOC^{3}IPT must be based on a distributed hypermedia database. A distributed hypermedia database is a collection of multimedia data that belongs logically to the same system but is physically spread over the sites of a computer network. Below are listed some of the potential advantages of distributed hypermedia database systems:

- Distributed nature of ATOC^{3}IPT: The hypermedia database of the ATOC^{3}IPT will be naturally distributed over different locations. For example, the commander has different staff officers in the ATOC and has also his subordinates, namely battalion commanders and their staff in various locations. Each staff officer or commander may keep the hypermedia database related to his mission on his site. Each staff officer accesses only the data at his location, but the global users, namely commanders, or high level commands, may require access of information stored at several of these locations. Notice that the hypermedia database at each local site typically describe a "miniworld" at that site. The sources of hypermedia data and the specified users for the local hypermedia database will physically reside at that site. On the other hand, the above mentioned global users may only occasionally access such local data.
- Increased reliability and availability: These are two of the most common potential advantages cited for distributed databases [Elmasri89]. Reliability is broadly defined as the probability that a system is up at a particular moment in time, whereas availability is the probability that a system is continuously

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available during a time interval. When the hypermedia data and Database Management System (DBMS) software are distributed over several sites, one site may fail while other sites continue in operation. Only the data and software that exists at the failed site cannot be accessed; other data and software can still be used. This improves both reliability and availability. Further improvement may be achieved by replicating data and software at more than one site. In a centralized system, failure of that single site makes the whole system unavailable to all users.

- Allowing data sharing while maintaining some measure of local control: It is possible to control the hypermedia database and software locally at each site. However, certain data can be accessed by other remote sites through Distributed Hypermedia Database Management System software. This will allow controlled sharing of the hypermedia database throughout the distributed system.
- Improved performance: By distributing a large database over multiple sites, smaller hypermedia databases will exist at each site. Local queries and hypermedia information retrievals at a single site will potentially demonstrate better performance since they will process smaller local hypermedia databases. In addition, each site will have a smaller number of processes executing than if all processes were submitted to a single centralized database. Processes that involve access to more than one site may proceed in parallel, which can reduce the process and response time.

Distribution leads to increased complexity in system design and implementation. To satisfactorily achieve the potential advantages listed above, the Distributed Hypermedia Database Management System software must be able to provide additional functions to those of centralized Database Management Systems. Some of these are:

- Accessing remote sites and transmitting queries and data among the various sites via a communication network.
- Keeping track of data distribution and replication in the Distributed Hyperdatabase Management System catalog.
- Execution strategies for queries that access hypermedia data from more than one site.
- Deciding which copy of a replicated data item to access.
- Maintaining consistency of copies of a replicated data item.
- Recovery from individual site crashes and from new types of failures such as failure of a communication link.

2. Security Measures for the Database Management System

Database security is a very broad problem that addresses many issues. These include the following:

- Legal and ethical issues regarding the right too access certain information. Some information may be deemed to be private and cannot be accessed legally by unauthorized persons.
- Policy issues at the governmental, institutional, or corporate level as to what kind of information should be made publicly available.
- System-related issues such as the levels at which various security functions should be handled (for example, physical hardware level, operating system level, DBMS level) [Elmasri89].

In multiuser database system, such as in ATOC^{3}IPT, the DBMS must provide techniques to enable certain users to access selected portions of a hypermedia database without having access to the rest of the database. This is particularly important since a large integrated hypermedia database is to be used by many different users within the ATOC. Each staff officer has an application which is capable of accessing only a subset of the database. For instance, the Intelligence officer is able to view other staff officers overlays but only can modify intelligence overlays and intelligence databases of the created plans or change the environmental effects based on the incoming reports, whereas the Personnel officer can view other staff officers overlays and can only manipulate the personnel overlays and databases. Sensitive information should be kept confidential from most of the database system users. A DBMS typically includes database authorization subsystems to provide to ensure the security of portions of a database against unauthorized access.

Another security problem common to all computer systems is that of preventing unauthorized persons from accessing the system itself. Certain persons may want to gain access to the system illegally - either to obtain information or to maliciously change a portion of the database. This security mechanism is called access control and is handled by login process of the DBMS.

One other security technique that may be applied to hypermedia databases is data encryption. This technique is commonly used to protect from unauthorized access sensitive

data that is being transmitted via satellite or some other type of communication network. Encryption can also be used to further protect sensitive portions of the database.

Finally, there are significant issues concerning storage in hypermedia system. The data in a hypermedia environment have a diversity that conventional database management systems are not prepared to handle. The data objects can span an enormous range of size and format; new models of data management systems are needed.

Because the hypermedia database may contain a mixture of structured data (relations with fixed fields) and unstructured data (text and images etc.), the definition and access facilities must be more diverse than conventional database. These should provide the typical join and union operations for structured data queries, but also support unstructured text queries and eventually some form of query for image, video, graphics, nad sound. The indexing facilities should support retrieval of partial objects as well, which becomes important with large video and audio archives.

Hypermedia systems are generally built using an object paradigm. In terms of managing object-oriented data, important issues of version control and dependency mapping need to be addressed by the database management system. A general communication environment must allow users to create multiple versions of objects over time without burdening the storage resources. If any object is deleted or modified in some way, the object manager must access the other objects that are dependent on that object; in other words, it must be possible to trace dependencies through the database [Hodges90].

C. ARTIFICIAL INTELLIGENCE AND HUMAN FACTORS

Artificial Intelligence includes the study of how to make computers perform tasks that, until recently, only humans could perform. Hence, AI is "smart" computer software. One point of emphasis in AI research is to design computer programs, "expert programs," that capture the knowledge and reasoning processes of highly intelligent specialists.

The expert system is to be used to:

> • Identify the incoming messages (from 1st battalion etc.), media type (video, audio, text etc.), their priorities, security levels (Top Secret, Secret etc.) and, in

cooperation with the hyper system place them into the related databases, and display them on the related personnel workstations.

- Keep time and action logs related to the created plans, thus display the time related information anchors at specified times and on related personnel workstations.
- Determine information about the terrain and enemy that would otherwise be unknown. Example: Identification of mobility corridors. Mobility corridors may be generated through a process that diverts the operators attention from non-trafficable terrain by shading it differently from trafficable terrain. Another example may be to analyze information collected about the enemy forces to determine the enemy's situation and probable courses of action.
- Play the designed operational plan and give results and suggestions about the selected courses of action.
- Help the staff officers to follow the plan. For example, if the logistics support officer is concentrated on one situation, and there is an incoming message saying that company A of battalion B is running out of antitank ammunition supply, it will be displayed on the workstation of G-4 with a flashing icon(accompanied by an audible tone) which when selected will display the message sent by that company.
- Create and control semi-automated forces to play against forces created and controlled by commanders and the staff.

The most important aspect of an automated command and control system is a close-loop architecture:

- Be aware of the mission, sense the tactical combat environment.
- Evaluate how the environment affects the mission.
- Generate a corrective action plan.
- Execute the corrective plan and evaluate the mission performance.

The time constants associated with such an architecture range from seconds in an air combat to minutes for a tank platoon to many hours for a division. Practical systems must have a hybrid set of situation evaluation and decision generation techniques that range from rather rigid to flexible systems such as neural nets.

Systems must be conceptually layered: from concrete data we must generate more abstract information. Decisions are best made in this abstract information space, and the execution of decisions will require a re-translation into specific movement and engagement orders.

Many useful techniques are available today to create functions within the overall architecture mentioned above. One is the use of high-speed Artificial Neural Nets(ANNs) [Jaszlics93]. This approach is important when quick, complex decisions must be made.

The key elements in a closed-loop tactical control model are:

- A current situation assessment capability.
- A decision generation capability.
- A mission re-plan capability.

Each of these capabilities is characterized by the fact that they must present conclusions or decisions arrived at in an environment of uncertainty. There is either too much or too little information, and often it contains contradictory items. The problem is complicated by the fact that some decisions must be made with certainty, while others may be somewhat "fuzzy". ANNs offer the most promising method today for solving complex problems:

- They can "learn". The fact is that in a situation that would take an extremely large number of rules, and in which we might not be able to cover all possibilities, we can "teach" a neural net with a few examples of the "correct" behavior. There is no need to extract expert knowledge in a form alien to a tactical decision maker such as a battalion commander. The expert can merely state examples of what would be the right decision in such-and-such circumstance in a tabular form, and ANN "learns" how to make the decisions.
- They will always give an answer. This is also a weakness: if the teaching is inadequate, the decision may be wrong, and the net needs more teaching.
- They can be very fast -- an appropriate component even in a maneuver control and target acquisition system. This is shown by commercial, neural net-based optical character readers included in the latest FAX modem software.
- The processing is based on "data" rather than "code" -- they are therefore highly maintainable and can be re-directed with ease.

It is naive, however, to believe that ANNs alone can solve the information fusion and tactical decision generation problems in our ATOC³IPT. ANNs are a useful and necessary tool in tactical decision support. This includes applications for information fusion from multiple, often contradictory or inadequate, sources. It also includes decision generation, which may be used in automated command and control for simulated forces, in future applications for high-speed battle management, or in decision aids that provide recommended courses of action [Jaszlics93].

Human factors are very important in designing a model. Most decision support tools or simulation tools are not human-in-the-loop models for simple two reasons: lack of time and lack of budget. These constraints exhibit themselves, in practical terms, as a typical unavailability of appropriate, experienced, and critical players of sufficient quantity. The difficulty of incorporating appropriately-trained humans into a simulation (whether a wargame or not) precludes their use except when their decision, invention, or psychomotor attributes are most critical. In those cases, moreover, the number of variables which can be independently studied with any statistical validity is very small. The human element is often replaced by submodels which are supposed to mimic human behavior It is axiomatic that if the submodels do this by assuming "rational" or long-term optimal man behavior based on mathematical premises, they are not very realistic. There are three areas of endeavor in which these submodels have proven reliable, provided they have been verified against real-world data. These submodels relate to limited subsets of the following kinds of human activity:

- Psychomotor responses.
- Cognition and recognition.
- Human decisions of a relatively straightforward "if-then" type, such as can be expressed by deterministic sequences [Hughes89].

The ATOC^{3}IPT is considered to be human-in-loop type model. Its users must be experts in their fields. Thus they may teach the expert system and ANN adequately. Nevertheless the ATOC^{3}IPT user interface has to be simple enough to be understood by each person working in ATOC so that, if need arises, it will be possible to give one staff officer multiple responsibilities.

VI. CONCLUSION

With applicable technology increasing exponentially over time, automation will be an ever-more pervasive part of command, control, communications, and intelligence(C^3I). As such focus of developmental efforts for C^3I support systems must be to harness technology in a way beneficial to the commanders of tactical units. Technology must be made to serve the commanders, to make his job easier, to enable him to achieve more with the same effort or resource. Any new automation must make C^3I procedures simpler and easier to perform than the manual or earlier automated process it replaces. The experience of researchers in the field of automation shows that whatever is done must make sense and simplify the tasks of the commander and staff in order to inspire their confidence in the system, or they simply will not use it[Wayne90].

The main focus of this work is to examine the design and implementation of an Automated Tactical Operations Center Command, Control, Communications, and Intelligence Planning Tool which incorporates multimedia technology with military tactical planning. Discussions of results in this chapter revolves around three main areas. The first concerns the advantages of automation of the tactical operation center(TOC) with usage of proposed tool. The second deals with the disadvantages of such automation. The last deals with recommendations for future research.

A. DISCUSSION ON ADVANTAGES OF TOC AUTOMATION

Commanders need information about the enemy, about the environment in which an encounter may take place, and about the status and capabilities of their own forces. They need information about objectives: not only must they be clear about their own, but they must know those of superior commanders. They need a sense of what is possible - a database of options based on their knowledge, their training and experience, the advice of their staffs, and any other available sources. Once a commander's decision is made, it takes the form of an order. Orders are also information - information about what is expected of

each player in the operation. When the action begins, the commander needs information in the form of feedback. Is the plan working? How must it be modified? The more commanders know and the faster they know it, the more likely it is they will be able to outwit and confuse enemy commanders. The ATOC^{3}IPT allows commanders to see further, control larger forces, access and digest more data in a given amount of time, and make decisions faster and more reliably.

Affordability dominates system considerations as decreasing budgets force tough decisions on program developments. High-cost systems attract the attention of budget cutters looking to conserve limited funds for the many competing weapons, manpower, force structure and support system programs. ATOC^{3}IPT is affordable since it is designed to use off-the-shelf hardware and software. It provides increased performance, reliability and mobility at less cost. The ATOC^{3}IPT offers a networked environment for the commanders and stuff officers of all echelons thus supporting interoperability.

When we consider effective automation, we must know our real needs. The following questions should be asked and answered positively to validate the automation process:

- Does it save time or manpower?
- Will it provide a new capability?
- Is this new capability really necessary?
- Will we use it frequently enough to justify the expenditure?

If the answer to any of the questions is no, then it fails to pass the common-sense automation test. When we ask these question for ATOC^{3}IPT the answers to all are Yes. There are many advantages of automating the TOC with such a tool:

- ATOC^{3}IPT provides the commanders and their staff accurate 3D display of the actual terrain of operations. The terrain database gathered by satellites and interpreted by the system may have a resolution of one to one hundred meters. This provides a very realistic model to use in planning the operations, much better than depending on sand table models prepared in classical TOCs. This provides a new capability while replacing an old method.
- The Overlay design tools designed in ATOC^{3}IPT provide the staff officer and commanders with fast situation map development. They contain predefined 3D representations of various military symbols used in classical overlay

development. Designers may travel over the terrain with one meter resolution. Thus they may explore the terrain, both friendly and enemy territory, with great accuracy. In the classical approach the plan designers have to make reconnaissance expeditions to the terrain of operations, if possible. These tools save a great deal of time and manpower.

- The users of ATOC^{3}IPT are able to create and retrieve various media of information like video, text, audio, and graphics about units, personnel, enemy forces, etc. This capability is not possible in classical planning tools.
- By using the expert system, the commander and the staff are able to achieve instant multimedia references of tactical information.
- The commander and staff can design their plan, play it, modify and replay it. They can view the playing of the plan on the virtual world display, free to move around the terrain as they wish. They can get an idea of the outcomes of certain courses of actions.
- The ATOC^{3}IPT provides the users with realistic representation of environmental effects on the battlefield. Classical overlay editing tools do not have such a capability.
- Networking capability provides the users of the ATOC^{3}IPT the ability to exchange information with other TOCs and information gathering devices in real or near real time. This information is immediately accessible from within the virtual environment, enabling one to build a visual and time-based context from the information.

All of the above mentioned advantages and new capabilities enhance the tactical operations planning process. They are currently either done manually, or not done at all. The functions of ATOC^{3}IPT are essential for the tactical operations planning process of the TOCs in today's technological battlefield environment. Besides saving time and manpower, such an implementation of modern technology into the combat decision making process will save lives.

B. DISCUSSION ON DISADVANTAGES OF TOC AUTOMATION

Although there are many advantages of automating the TOC processes with ATOC^{3}IPT, advanced technology brings with it its own limitations and vulnerabilities. Devices and systems may assist, but never replace, the commander's decision-making responsibilities.

The C^3I process involves more than technology, and efforts to improve these processes will fail if we limit them to technical fixes. The best equipment in the world won't do much good of people don't know how to use and maintain it, or if commanders don't recognize its capabilities or understand how to make best use of those capabilities, working around the equipment's limitations. Heavy reliance on technological solutions may prove disastrous in the event of equipment/software malfunction or compromise. While it allows commanders to do more with less, provides extraordinary sensors, intercept devices, communications functions, and storage capacities, high-tech C^3I equipment and software such as ATOC^{3}IPT also creates the problem of information overload. Having the most data isn't necessarily a component of victory. Decisionmakers, including commanders at all levels, often need particular pieces of information rather than mountains of data. It is may be more important at a given time to know the single fact that an enemy is moving its reserve to a certain point, than to have a large database of detailed technical data on all the weapons systems the enemy possesses. An expert system in ATOC^{3}IPT can act as a filter system or a fusion system between the data collection points and the users of the tool. As a filter system, the expert system pulls out and makes available to the specified user only that data which would be helpful to him or her. As a fusion system would, it converts all available data into a condensed, more easily digested form e.g., graphics, tables, etc.

Technological improvements in TOCs are in practice designed to sharpen a combat unit's fighting capabilities, but advanced equipment such as ATOC^{3}IPT, requires extensive training for users as well as maintenance personnel.

The automated systems could become a blinder to the commander. The primary components of such automated system's expert systems are history and logic. History contributes the "rules"; logic drives their application to the battlefield. But the history may be misapplied or the logic can be misleading. The user of such automated tools should not blindly rely on decisions/recommendations given by the expert systems.

Another disadvantage may be defined as an overconfidence resulting from knowing one is using the superior technology. We must keep in mind that weak, unhappy, or unbalanced individuals may be involved in the design, production, deployment, operation, and maintenance of today's complex systems. They may bring about the sudden loss of technological advantage.

Computers and the software that drives them are designed and put together by human beings as flawed as any others. Even the best, most thoroughly tested software carries hidden glitches that can freeze the computer at a critical moment. Environmental e such as humidity, heat, cold, chemical environment, etc. may create adverse effects on computer systems.

Another problem associated with technology is dependence. One must be prepared to operate without the automated systems, in the event their use is denied. Backup procedures need to be developed and practiced before they are needed.

C. RECOMMENDATIONS FOR FUTURE WORK

The main focus of this work is proof of concept. We present some of the research areas required to make the ATOC^{3}IPT more effective as a practical tactical decision making and training tool.

1. Hyper System Design and Implementation

As the commander's and staff's information requirements become more complex there is a need for more sophisticated hyper-system design and implementation. One approach may be to design a hyper-system which will be capable of keeping track of multiple numbers of Information Anchors with more than the present node types which may have capacity of holding multiple video, audio, graphics, and text media files. The Information Anchors may be both stable and moving. The hyper-system may be improved to relate the Information Anchor display to the system clock, so that some specific anchors may be displayed only at specific time periods.

2. Hyper System Database Design and Implementation

The database of ATOC^{3}IPT should be implemented as previously described. Various terrain types should be entered into the terrain database. The environmental effects database must be created and implemented into the system. Also remote modification, information retrieval when the system is networked, has to be considered, and a distributed database management system has to be implemented to coordinate sharing of the common databases by various echelon units. The relation of the hyper-system, expert system, database triology should be reexamined and implemented to support the functionality of the tool. E   tive algorithms and data structures have to be designed and implemented in order to spee   p the functionality of the tool.

3. Expert System Design and Implementation

Implementation of an expert system which will make the coordination of data flow from and to external units and TOCs is essential for the practical usage of ATOC^{3}IPT. The relationship between the expert system and the hyper-system must be examined and implemented. Implementation of autonomous forces is another important aspect to be considered while implementing the expert system.

4. Network Design and Implementation

The natural evolut   of the most battle simulator software is toward having networking capabilities. In order to support the distributed database system notion of the ATOC^{3}IPT, and to give timely information to its users networking is inevitable.

5. Hypermedia Authoring

Hypermedia authoring tools should be implemented into the system to allow users to create their own video, audio, graphics, and text databases or their combinations. Remote hypermedia authoring should be designed and implemented. The user cannot easily view video clips, for instance, before assigning them to the information anchors. The ability to view video and graphic files and listen to audio files during the authoring process would

streamline the authoring process and minimize the time spent in designing hypermedia operational plans.

6. Hypermedia Querying

Hypermedia querying methods can be improved to provide the users with more detailed information. The links between various media information nodes must be constructed so that for instance when the user watches the video information of the anchor, he can also view the text file related to it, or view its graphics files, or listen to its audio information. Remote hypermedia querying techniques should be developed to support networking implementation.

7. Graphical User Interface Improvement

As the hyper-system, expert system, and hyper-system databases evolve and the system becomes networked, the GUI will also undergo a redesign. The functions described in Chapter IV, GUI design, must be implemented and during implementation new capabilities must be considered.

VII. ATOC³IPT USER MANUAL

Much of the detail concerning using ATOC³IPT has been described in various places throughout the body of the thesis. To simplify the learning process, a brief user manual is included here. As the tool's functions are partially implemented, we explain only the implemented part here. For functionality of the complete model please refer to Chapter IV.

A. STARTING AND EXITING THE PROGRAM

The current directory must be *~serbest/thes/hyperX*. ATOC³IPT is started at the command prompt by entering:

>*X*

To quit ATOC³IPT, use the *Quit* button in the initializing window (see Figure 15). Press the *Commander* button to start the application. The security check dialog box will popup (Figure 16). Enter a string of characters for security checking into the textfield in the security check dialog box, for example: "F1816S", press the *OK* button. Now the main application window will popup and the security check dialog box and initializing window will be iconified. You may use the *Exit* selection from the *Plan* pull-down menu to quit the application.

B. CREATING A NEW PLAN

Blank hypermedia plans can be established using the *New* selection from the *Plan* pull-down menu. When you press the *New* button, the *New Plan* dialog box will popup (see Figure 18). Enter a string to specify the new plan name into the *New Plan Name* textfield, for example "NNNN". Press the *Done* button. This operation creates a "NNNN.plan" directory under the *Attack.op* directory and a file "OVERLAYS" under the *NNNN.plan* directory.

C. LOADING AND SAVING HYPERMEDIA DATABASES RELATED TO THE OPERATIONAL PLAN CREATED BY THE USER

Existing hypermedia plans can be loaded using the *Open* selection from the *Plan* pull-down menu. When the *Open* button is pressed, the *Open Plan* dialog box will popup. In this dialog box select a desired plan from the scrolled list *Plans* on the right. When a plan is selected its full path is displayed in the *Plan Selected* textfield. For example select "DEMO.plan". Press the *Apply* button. The hypermedia database related to the DEMO.plan is loaded into the hypersystem, and now we are ready to display or modify the desired information anchors and overlays in that plan. Select the *Texturing on* button from the *Display* pulldown menu if you are on the reality engine. If you are using an Indigo or Indy workstation the texturing will slow your movements in the 3D terrain. Select the *All overlays on* button from the *Overlays* pulldown menu under the *Display* pulldown menu. All the information anchors will be displayed on the virtual sand table with their corresponding colors: *Personnel* anchors are displayed in *black*, *Intelligence* anchors are displayed in *red*, *Operatiois* anchors are displayed in *blue*, *Logistics* anchors are displayed in *green*, *Civil affairs* information anchors are displayed in *yellow*, and the *Unknown* and *Terrain* general information anchors are displayed in *magenta*. You can close all overlays by selecting the *All overlays off* button form the same menu. You can display one overlay or multiple overlays at the same time. Say we press *Personnel overlay on*. The *Personnel* information anchors will be displayed. If we then press *Intelligence overlay on*, *Intelligence* information anchors will also be displayed beside the *Personnel* anchors. Thus you can retrieve and modify the desired information from the desired overlays.The modified and created plans are automatically saved into the hypermedia database. Now go and select the *All overlays on* option. We have all the information anchors displayed on the virtual sand table. When we close the overlays they are automatically saved into the hypermedia database of the selected plan.

D. MOVEMENT THROUGH THE VIRTUAL SAND TABLE

To move through the virtual sand table, use the left and middle mouse buttons, and to stop and look around use the right mouse button. To move forward use the left button and to move backwards, use the middle button. When buttons are pressed in the move mode, a square red outline appears in the middle of the virtual sand table window. Motion will be straight forward or backward, depending on which button was pressed, as long as the cursor is kept within the red square. To turn merely move the cursor in the direction of the desired turn. Move the pointer left of the box to turn left and right of the box to turn right. If the pointer is moved above or below the box, the pitch will be changed to a climb or descent, respectively. The further the cursor is from the red box, the faster the rate of turn or pitch.

Forward and backward motions are constant speed. If the user becomes disoriented, the initial view can be restored using the *Reset View* button on the *Display* pull-down menu.

E. TO CREATE OR EDIT HYPERMEDIA DATABASE RELATED TO THE OPERATIONAL PLAN

Previously we loaded the Demo.plan into the system and selected the *All overlays on* option from the *Display* menu. If you wish, you can create a new plan and continue on. Now we are ready to edit new Overlays or to modify the existing Overlays. There are currently two types of editing features in the tool: *Auto Anchor editing* and *Manual Anchor editing*. By editing we actually create Information Anchors in the related Overlays. Under the *Edit* pulldown menu there are two Information Anchor creation options: *Overlay* and *Anchor*. Overlay is a cascade button which gives selection of various Overlays we want to edit, namely *Personnel, Intelligence, Operations, Logistics*, and *Civil Affairs*. The user must select a desired overlay in order to start editing. As an example let's assume the user chooses editing a *Personnel* overlay. An overlay editing tool window (see Figure 25) will pop up. The user selects the icon related to the information he wants to edit. For an example let's select the *Labor resources...* icon. Now a new dialog box: *New Anchor Orientation Dialog Box* (see Figure 26) pops up. The user may orientate the new Anchor by using the

X, *Y*, *Z* sliders. Fine adjustments may be accomplished by pressing the up and down buttons on the keyboard while the mouse pointer resides on the related slider. When orientation is done the user hits the *Ok* button and the *Auto Anchor Edit Dialog Box* will pop up. This dialog box is the same as the *Anchor Edit Dialog Box* (see Figure 27), only now the type of the Information Anchor and its coordinates are automatically entered by the system. This feature allows the user to move in the 3D environment and place the Information Anchor without having to know or remember any coordinates. The user only has to fill in the name of the anchor, orientation if any, and the related audio, video, graphics, and text files into the specified text fields. The user must click on the desired textfield with the left mouse button and then use the keyboard to enter the strings. Now click on the name textfield and enter the name of the new information anchor, i.e. "New Labor Camp #". As soon as we click on any textfield the **Save** button option is made available. The names of the multimedia files must be given as complete paths. Use the same clicking method for the other textfields. For instance, if we insert a graphic file it must be in the following format: */n/elsie/work3/serbest/thes/graphic/m1.sgi*, for text file information enter: */n/elsie/work3/ serbest/thes/hyperX/X.C*, for audio information enter: */n/elsie/work3/serbest/thes/audio/ forest.aiff*, for video information enter: */n/elsie/work3/serbest/thes/videos/73east_1*, or you can enter any desired file by entering its exact path. After entering the related information the user must press the *Save* button to save the edited *Information Anchor*. Then by selecting the *Cancel* button you can close that dialog box. Thus we created an information anchor with four types of media information attached to it.

The same procedure is followed in Manual Editing, by which we mean selecting the *Anchor* option on the *Edit* pulldown menu. The *Anchor Edit Dialog Box* will pop up. The user has to enter the name of the anchor, its type, its orientation, its coordinates, and the paths of the four media files if he wants to attach any. When the *Save* button is pressed the created *Information Anchor* will be saved into the related hyper database. The *Unknown* and *Terrain* general information anchors are edited by this editor.

F. DISPLAY OPTIONS

The user may select the *Anchors* option under the *Display* pulldown menu, and the *Anchor Information Dialog Box* (see Figure 33) pops up. This dialog box includes a list of all *Information Anchors* associated with the current plan depending on the type specified by the user when selecting the Anchors display option. For example if the user selects the *Personnel* option under the *Anchors* menu of the *Display* pulldown menu, in the scrolled list of the popping dialog box only the personnel information anchors' names will be listed. Thus the user can specify which information anchors he is interested in. The names will be listed even if the overlay has not been displayed, so the user can jump to that location. Then the user selects the desired anchor and by pressing the Jump button he can jump to the location of the *Information Anchor*. He can also press the *Back* button to go back to the previous selection. On the right side of the dialog box there are five drawn buttons, which are highlighted whenever information related to them is attached to the anchor. Let's assume that all four types of information are attached to the selected anchor. When the user presses the *Video* button the *Video Files* popup dialog box opens (see Figure 34). On the left side of that dialog box there is a list which contains the name of the video file to be displayed, and it is selected. When the user presses the play button under the screen field, the selected video is played in the screen field. The user can close that dialog box by pressing the *Done* button. When the user selects the *Audio* drawn button from the *Anchor Information Display* dialog box, the *Audio files* dialog box pops up (see Figure 35). It has a scrolled list which contains a selected audio file to be played. You must be working on an Indigo2 or Indigo workstations to get the audio effect. You can play the audio file by pressing the *Play* button. By pressing the *Done* button the user can close that dialog box. When the *Graphic* drawn button is selected another dialog box pops up (see Figure 36). Here we have a list with a highlighted graphic file to be displayed. When the user presses the *Show* button a window named *Graphic* pops up and displays the selected graphic file. The *Show* button must be pressed again to close the graphic display window. to close the *Graphic files* dialog box press the *Done* button. Another option in the

Information Anchor Display dialog box is the text media display. Select the *Text* drawn button, and the *Text files* dialog box will popup (see Figure 37). Here is a list with highlighted text file to be viewed. Press the *Show* button to view the file or press the *Done* button to close the Text files dialog box. If the text file is viewed a window containing the selected text file pops up. The user can close it by pressing the *Show* button again. For the moment the lists in these dialog boxes include only one name depending on whether any information is attached to that *Information Anchor*. From the *View* option the user opens the *View Dialog Box* (see Figure 39). Here he can manipulate his location by moving the X, Y, Z sliders.

G.   ANCHOR SELECTION AND MULTIMEDIA QUERYING

One other Information Anchor select option is provided by setting the mouse status to *Query*. Before setting the mouse status the desired overlays should be selected and displayed. Thus the user can select the desired Information Anchor by clicking. Then the *Anchor Information Dialog Box* will list all the anchors of the selected anchor type and the selected anchor will be highlighted. Thus the user can jump to the selected anchor location or get the multimedia information associated with it, or he can select another information anchor of that type and retrieve the multimedia information available to it.

Another method of retrieving the multimedia information is to first select the *View* option from the *Display* pulldown menu. Now from this dialog box we can select the media: video, audio, text, graphics. This method allows the user to browse in the multimedia database and retrieve all the video, audio, graphics, and text files and display any of them. For example, when we press the *Video* button, we initiate a new dialog box: *View Video files* popup dialog box (see Figure 40). This dialog box is almost the same as the *Video files* dialog box, except on the left side of the dialog box we have radio buttons from where the user can select his area of interest: *Personnel, Intelligence, Operations, Logistics, Civil affairs,* and *All.* In the scrolled list only the video files related to the area of interest selected by the user will be displayed. the user can select any of these video files,

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and the selected file name will be displayed in the selected file textfield. By pressing the play button the user can play the selected video

H.   MODIFYING THE HYPERMEDIA DATABASE

The user can modify the hypermedia database related to the selected plan and overlay by using the *Anchor* selection from the Edit pulldown menu. By modifying the hypermedia database we mean modifying the multimedia information attached to various information anchors. First we select the desired anchor from *Anchor Information Display* dialog box or by setting the mouse to query mode and clicking to the desired information anchor. jump to that anchor using the *Jump* button. Then we select the *Anchor* option from the *Edit* menu. Now the *Edit Anchor Dialog Box* will pop up. Press the *Revert* button and now the dialog box will be displaying the information about the selected *Information Anchor*. Now the user can change the information in the dialog box. Click on the desired textfield with the mouse and use the keyboard to enter the changes. He can change the information anchor's name, coordinates, multimedia information etc. When it is saved the *Information Anchor* is saved with the newly modified information.

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